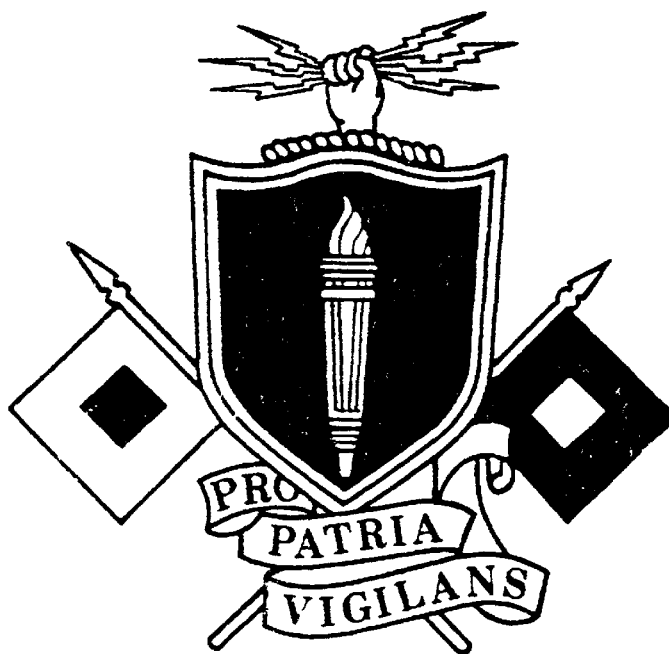


SUBCOURSE  
SS0511

EDITION  
3

COPY PHOTOGRAPHY I



THE ARMY INSTITUTE FOR PROFESSIONAL DEVELOPMENT  
ARMY CORRESPONDENCE COURSE PROGRAM

A  
I  
P  
D



US ARMY VISUAL INFORMATION/  
AUDIO DOCUMENTATION SYSTEMS SPECIALIST  
MOS 25S SKILL LEVEL 1

AUTHORSHIP RESPONSIBILITY:  
VISUAL INFORMATION/CALIBRATION  
TRAINING DEVELOPMENT DIVISION

## COPY PHOTOGRAPHY I

(Developmental Date: 1983 )

SUBCOURSE NO: SS0511-3

US Army Signal Center and Fort Gordon  
Fort Gordon, Georgia

8 Credit Hours

## GENERAL

As a military photographer you will, from time to time, be required to perform copy photography. It is necessary that you know and understand what is involved in copying something, be it a drawing, map, another photograph, or similar flat-plain object. Photographic reproduction is one of the most versatile of the copy methods. It is used widely throughout the military for preserving or improving a photographic print or document. This type of reproduction is a photographic function, and specific techniques must be applied to remove the guesswork and to minimize or eliminate mistakes in exposure, lighting, film, or developing.

This subcourse will provide you with the basic knowledge necessary to perform copy photography as a still photographer.

The subcourse is presented in two lessons. The lessons correspond to a learning objective as listed below.

### Lesson 1: Copy Camera Functions

**TASK:** Identify the term "copy photography", copy cameras and be able to describe the components and function of various types of copy cameras.

**CONDITIONS:** Given information, illustrations, and procedures about copy photography,

**STANDARDS:** Demonstrate competency of the task skills and knowledge by by responding correctly to at least 70 percent of the multiple choice and true or false questions covering the procedures, objectives, equipment, techniques and procedures to perform copy photography.



The objective of this subcourse support the tasks in STP 11-25S13-SM-TG, published in March 1989, as follows:

- 113-578-1005 Photograph subjects with a 35mm Single Lens Reflex Camera.
- 113-578-1007 Obtain Light Readings Using a Photoelectric Light Meter.
- 113-578-1008 Illuminate a Subject with Photoflood Lamps.
- 113-578-1010 Operate View Camera.
- 113-578-1012 Perform Copy Photography Using Camera Set KS-7A.

**NOTE:** Any reference to MOS 84B has been changed to  
MOS 25S effective 1 October 1988.

## TABLE OF CONTENTS

Section	Page
TITLE PAGE .....	i
TABLE OF CONTENTS .....	ii
Lesson 1: COPY PHOTOGRAPHY .....	1
ANSWERS TO PRACTICE EXERCISES ONE .....	77
Lesson 2: LENS OPTICS .....	82
ANSWERS TO PRACTICE EXERCISES TWO .....	117



## LESSON 1

### Lesson Objective:

When you have completed this lesson you will be able to:

1. Explain the term "copy photography".
2. Identify the basic copy cameras and the situations in which they are most likely used.
3. Describe the components and functions of the following copy cameras:
  - a. 35mm REPRONAR slide copier.
  - b. 4x5-inch view camera.
  - c. 8x10-inch copy camera.

These objectives support the following tasks:

- |              |  |
|--------------|--|
| 113-578-1005 | Photograph Subjects with a 35mm Single Lens Reflex Camera. |
| 113-578-1007 | Obtain Light Readings Using a Photoelectric Light Meter    |
| 113-578-1008 | Illuminate a Subject with Photoflood Lamps                 |
| 113-578-1009 | Load a Cut Film Holder and Film Pack Adapter               |
| 113-578-1010 | Operate View Camera  |
| 113-578-1012 | Perform Copy Photography Using Camera Set KS-7A            |

### 1-1 Introduction

There are many types of cameras that can be used for copying. In reality, ANY camera can be used for copying something; but in most cases, the end result is not ALWAYS what you want it to be. So to keep matters simple and to provide the needed knowledges in performing copy photography, we will stay with the basic camera formats used in the military service today. They are 35mm, 4x5 inch and 8x10 inch format cameras. We will take one format size at a time; identify and describe each one.



## SECTION I

### IDENTIFY COPY AND COPY CAMERAS

1-2. The term "copy photography" is usually considered to be photography of flat material. Things like charts, maps, diagrams, photographs, documents, and drawings when photographed are said to be copied. Even though all photography is really a reproduction of the original, the word reproduction is taken to mean "copy". The term "copy", therefore, is accepted to mean "reproduction of a two-dimensional original".

a. 35mm format is most commonly used to produce 35mm color or black and white (B/W) slides by copying charts, maps or any other flat surface material. This can be done with most types of 35mm cameras. When it comes to copying (duplicating) color slides and transparencies, the equipment best suited for this is the 35mm REPRONAR (fig 1-1). This equipment will provide copy with a minimum loss of detail and colors.

b. Components of the REPRONAR include a special purpose camera, an easel with slide and filter holders, an electronic flashlight source, a transparency viewing light, and an adjustable exposure calculator. We will explain the functions and specifics of copier the REPRONAR later in this lesson.

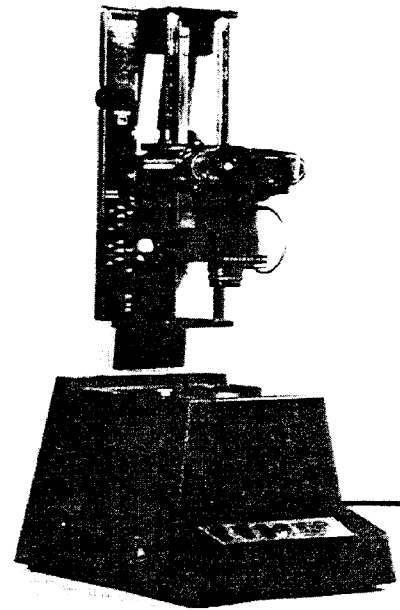


Figure 1-1. REPRONAR slide copier.





c. The 4x5-inch camera is one of many formats used in the Army today. It is used for portraits, full-length, investigative, equipment reports, and copy. The list can go on and on. The most commonly used 4x5-inch format camera is the 4x5 press camera, which is highly portable and can be carried around by the photographer from location to location without too much trouble. This type of camera is usable for performing copy photography, but it is not the ideal 4x5-inch-type camera because of its limited functions and capabilities.

d. A better suited camera is the 4x5-inch view camera (fig 1-2). This camera is portable, but must be used together with a tripod. It has numerous adjustments and compensating factors that are needed when using this type of camera for copy photography.

(1). The 16-inch bellows gives you the capability to use a variety of focal length lenses. This allows you to move in very close for small objects like wall maps and charts. It has front and back adjustments that swing, rise, and tilt.

(2). Later in this lesson we will discuss the function and operation of the 4x5-inch view camera (KS 17A).



Figure 1-2. 4x5 view camera.



1-3. The largest camera available in the Army is the 8x10-inch copy camera KS-7A. Due to its size and being nonportable, it is used in a fixed location such as a post photographic laboratory facility, or the Training and Audiovisual Support Center (TASC). The 8x10-inch format camera can provide the following color and B/W products:

8x10 negatives.  
8x10 transparencies.

4x5 negatives.  
4x5 transparencies.

Polaroid prints.

- a. It is primarily used for copying large flat items, such as large charts and maps. It can produce 1:1 negatives or transparencies, and enlarge small areas. This camera has the capability of reducing or enlarging copy by 4 diameters. This is all possible because the camera's focusing capability extends from 15 to 60 inches.
- b. The camera consists of a front frame which holds the lens board, front and rear bellows, rear frame which holds the reversible 8x10-inch ground glass and 4x5-inch ground glass for focusing. Both the front and rear frames can be moved manually to focus.
- c. Figure 1-3 shows an 8x10 camera set, Still Picture KS-7A, with components. This camera is most commonly used for copy work in the military today; but, here again, it all depends on the final product, whether it is to be a 35mm transparency, an 11x14-line copy, or large color print. The size of the original and final product desired will dictate the format you should use.
- d. We will cover the functions of the KS-7A camera later in this lesson when we talk about copying large objects for large reproduction.



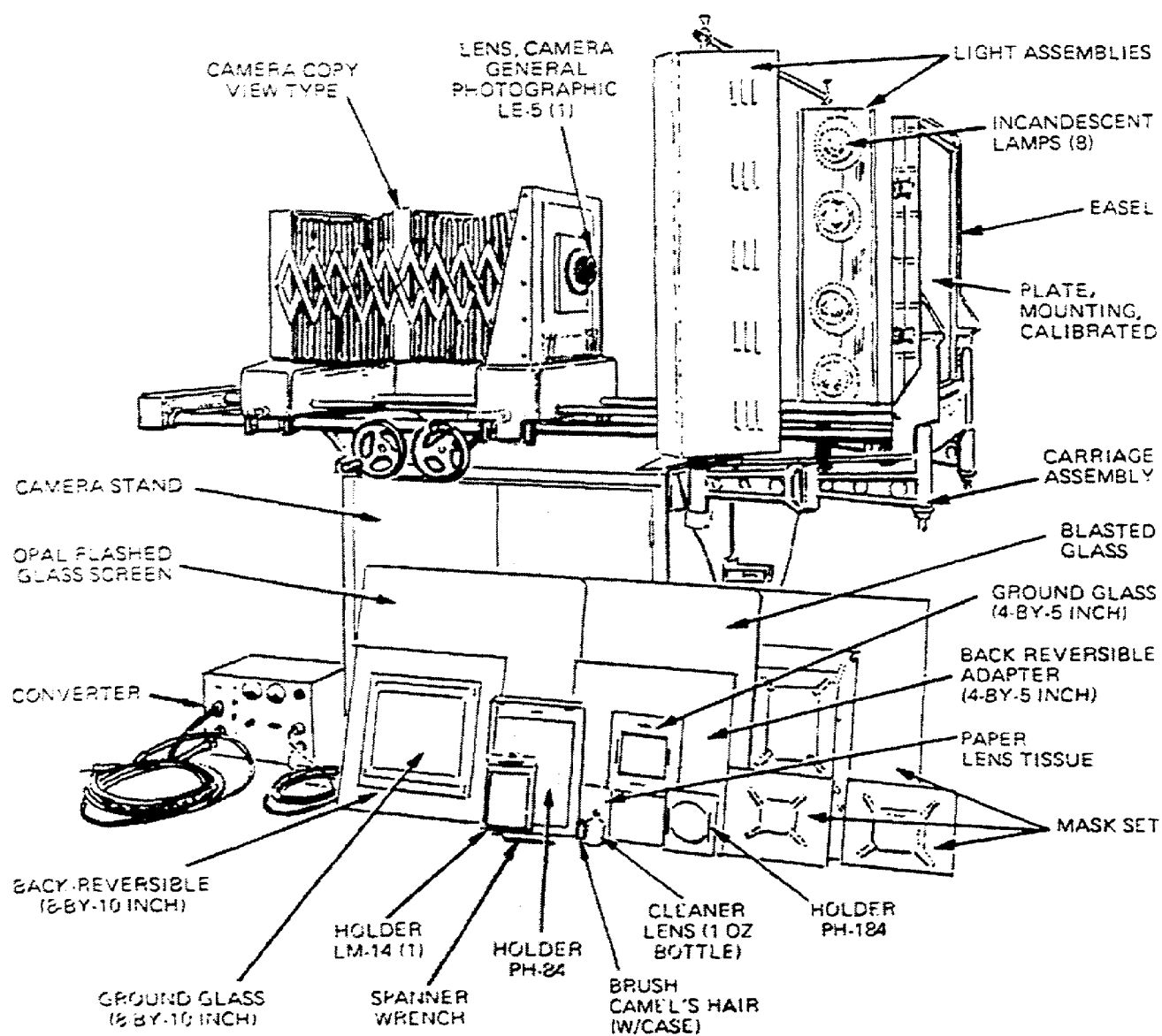


Figure 1-3. Camera Set, Still Picture KS-7A.



---

## REVIEW EXERCISE

1. Your section NCOIC gives you six 35mm, color slides and tells you that he needs five copies of each slide. Which camera should you use? (Circle one)

VIEW CAMERA, REPRONAR, KS-7A.

2. Which camera will give you first time copy in an 8x10-inch transparency format? (Circle one.)

VIEW CAMERA, REPRONAR, KS-7A.

3. Your next assignment for the day is to go out to a unit CP (command post) and make copies of charts. The finished product is to be 8x10 B/W prints. Which camera should you use? (Circle one.)

VIEW CAMERA, REPRONAR, KS-7A.

---

## SECTION II

### 35MM REPRONAR COPY CAMERA OPERATION.

1-4. It is hardly practical to disassemble a large combat tank in a classroom. Instead, drawings, diagrams, photographs and slide presentations showing how to do something step-by-step is cost saving, and can be made into a self-pace study program. This is where you come into the "picture," when you have to reproduce learning material into slides and photographs.

REPRONAR SLIDE COPIER is a 35mm single lens, reflex camera (commonly known as 35mm SLR) equipped with an f/4 copy lens especially designed for duplicating color slides.

We will now identify the major items and their functions on the 35mm REPRONAR copy camera, beginning with the parts facing you as you get ready to use the REPRONAR.





a. Film Advance Lever (fig 1-4). 1 - advances the film and cocks the shutter in readiness for the next exposure. Shutter Release Button 2 - operates the shutter and fires electronic flash in synchronization. Exposure Counter 3 - shows how many frames have been exposed. Indicates numbers from -2 to 37. Automatically resets to -2 when camera back is released. Double Exposure Button 4 - allows the shutter to be cocked for multiple exposure without moving the film. Shutter Knob 5 - rotates as shutter is cocked (clockwise) and released (counter-clockwise), Acts as a selection for "I" and "TB" settings.

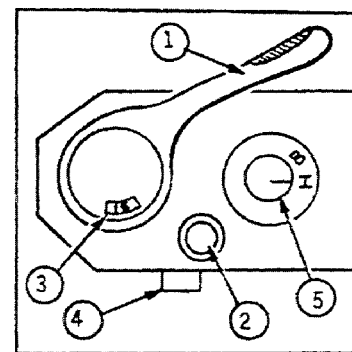


Figure 1-4. Left side.

b. Magnifier (fig 1-5) - enlarges a portion of the image for sharpest focusing. Swings up out of the way for normal viewing.

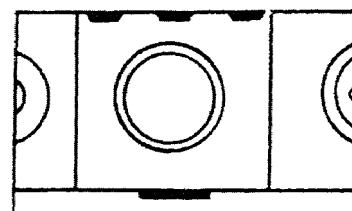


Figure 1-5. Center.

c. Crank for Rewind (fig 1-6) 1 - crank unfolds for ease of rewinding film into cassette. Film Reminder Dial 2 - may be used as a reminder of which kind of film is in the camera body. Camera Case Catch 3 - secures the removable camera back.

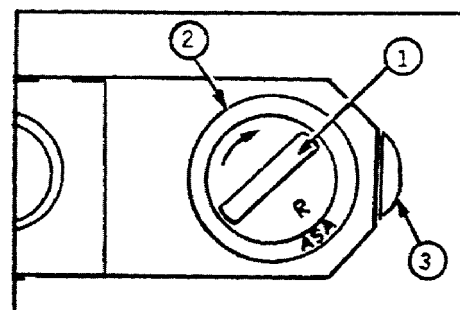


Figure 1-6. Crank for rewind, right side.



d. Aperture Selector (fig 1-7) - controls the action of the lens diaphragm (opens or closes down, with right to left movement).

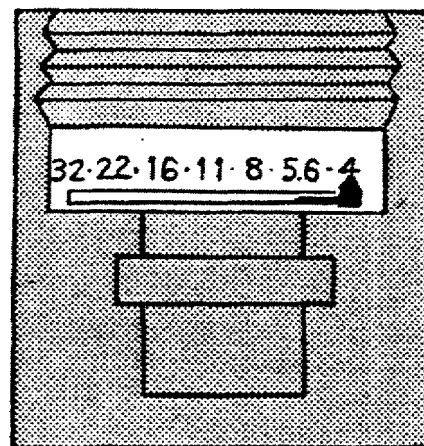


Figure 1-7. Aperture Selector.

e. Aperture Selector Pointer (fig 1-8) indicates working aperture which is printed on the aperture index scale.

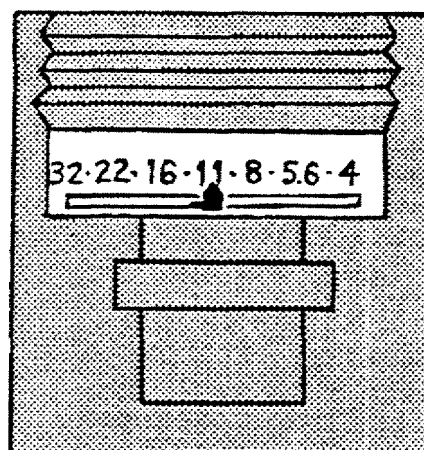


Figure 1-8. Aperture Selector Pointer.

f. Diaphragm Ring (fig 1-9) - rotates (click stops) to preselect the proper f/stop. The Aperture Selector will stop when being moved from right to left, at the position indicated by the Diaphragm Ring.

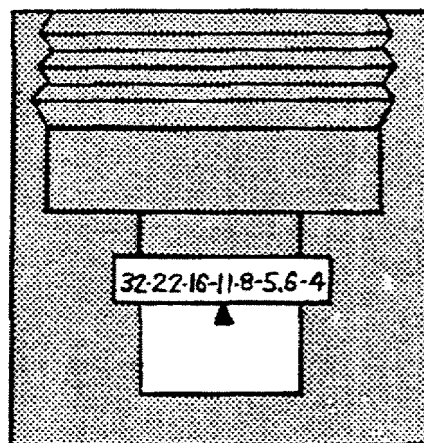


Figure 1-9. Diaphragm Ring.



g. Exposure Calculator Selector Wheel 1 – for selecting proper film index. Film Index Window 2 - shows choice of film index. Aperture Window 3 - shows correct aperture settings for different amount of magnification. Camera Aperture Bar 4 - gives correct aperture for various amounts of magnification. Magnification Scale-Lower 5 - used as reference points for the lens carriage pointer. Lens Carriage Pointer 6 - indicates on the Exposure Calculator the magnification of the copy and the lens aperture for a normal exposure. Camera Carriage Pointer 7 - indicates settings to correspond with the lens carriage pointer providing quick positioning of the camera for approximate focus. From this position, focusing is easily completed while the sharpness of the image is observed on the ground glass. Magnification Scale-Upper 8 - used as reference points for the upper pointer attached to the camera carriage. Lens Carriage Locking Screw 9 - locks lens carriage at selected position.

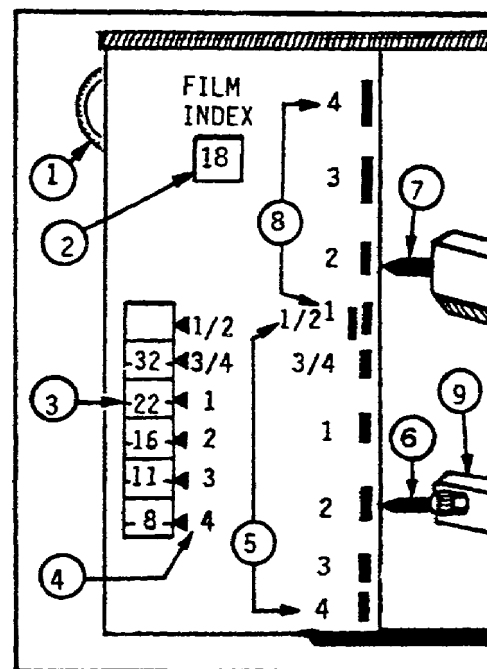


Figure 1-10. Exposure and Magnification Controls.

- (1) To select the correct aperture, adjust the focus and magnification. Read the numbers at the lens carriage 6 and camera carriage 7 pointers (fig. 1-10). In this case it reads 2. Go to the aperture window 3 and read the f/stop opposite 2. It shows f/16.
- (2) Set the aperture to f/16. Your camera is now set for the correct exposure.



---

## REVIEW EXERCISE

4. What must be operated in order to make an exposure with the REPRONAR?

---

---

5. You are making copies of slides with a REPRONAR. How do you check for the number of exposures made?

---

---

6. What must you do to insure the sharpest focus possible when copying a slide?

---

---

7. Where should the film ASA be set on the camera, as a reference point or reminder?

---

---

8. What is the function of the APERTURE SELECTOR?

---

---

9. You have decided to use a lens aperture of f/11. How do you set this on the camera?

---

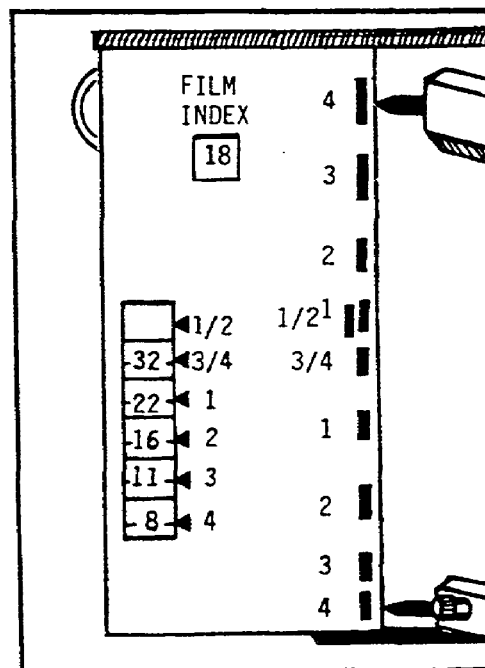
---





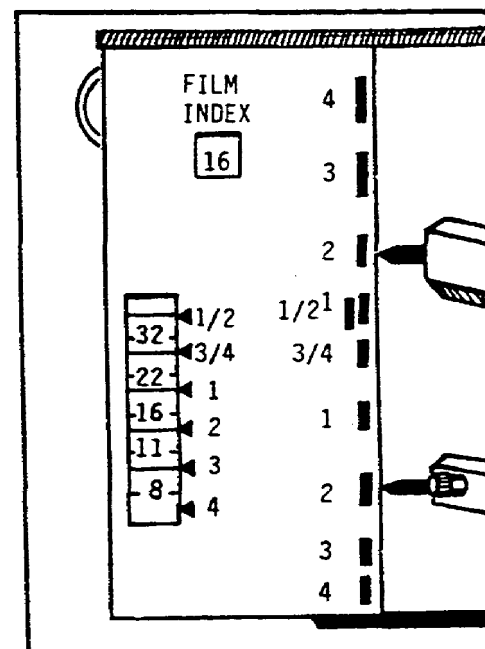
10. Using the illustration to the right, list the following settings:

- Film Index: \_\_\_\_\_.
- Camera Exposure: \_\_\_\_\_.
- Upper-Scale Magnification: \_\_\_\_\_.
- Lower-Scale Magnification: \_\_\_\_\_.



11. Using the illustration to the right, with a film value of 16 and an upper and lower magnification of 2, what is the camera exposure shown in the aperture window?

\_\_\_\_\_





h. Filter Compartment and Holder (fig 1-11). 1 - filter holder slides in and out of the filter compartment easily, allowing insertion of filter without disturbing copy or opal view glass 2 . The use of filters for color correction will be dealt with later in the course.

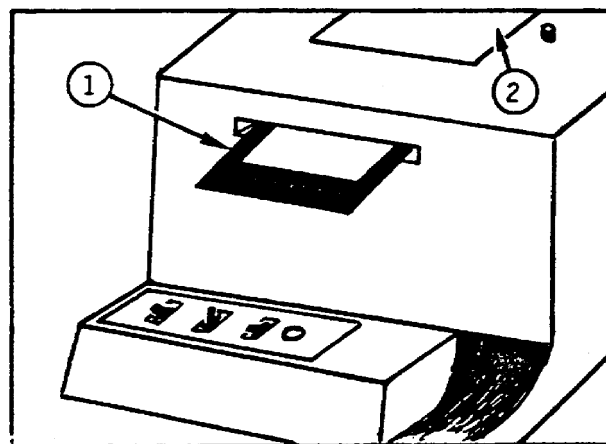


Figure 1-11. Filter Compartment and Holder.

i. Control Panel (fig 1-12). The control panel consists of three switches and a ready light. ON-OFF Switch 1 - functions as a master switch for the copier. The view light and electronic flash operate only when this switch is in the ON position. HIGH-LOW Switch 2 - controls power output of electronic flash. When in the HIGH position, the unit will deliver four times (two f/stops) the amount of light as when in the LOW position. FLASH-VIEW Switch 3 - in FLASH position, the switch completes the circuit for firing the electronic flash with the camera shutter release; in VIEW position, the switch turns on the view light for illuminating the transparency, for focus and framing. READY LIGHT LIGHT 4 - glows when the

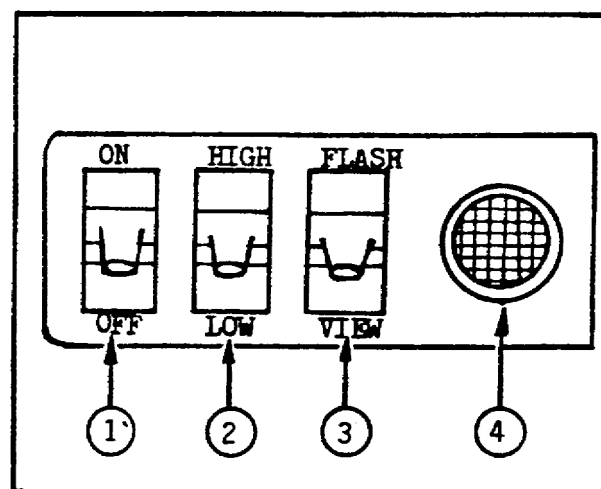


Figure 1-12. Control Panel

FLASH-VIEW switch is in the FLASH position, indicating that the copier is ready for operation - the view light is off and the electronic flash is ready to be fired.



j. Fuse Holder (fig 1-13). The Fuse Holder 1 - is located on back side of the REPRONAR base. It uses a 1.5 amp slow-blow fuse. If the unit is plugged into a live electrical outlet but does not operate, check this fuse first.

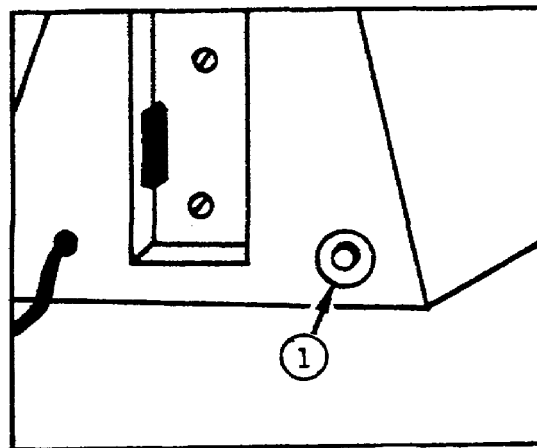


Figure 1-13. Fuse Holder.

1-5. LOADING THE CAMERA. In the following section you will get step-by-step instructions on how to load and unload the camera.

a. To open the camera back, pull the camera case latch (right corner) 1 out and the camera back will pop open (fig 1-14).

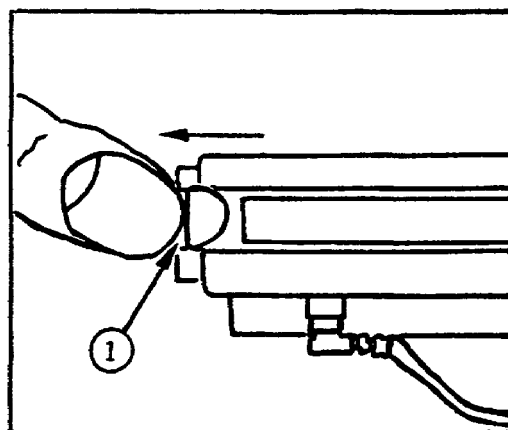


Figure 1-14. Opening Camera Back.



b. Lift the camera back off the camera (fig 1-15), both sides at the same time, insuring not to touch the focal plane shutter now visible in the center of the camera. Touching the shutter could damage it.

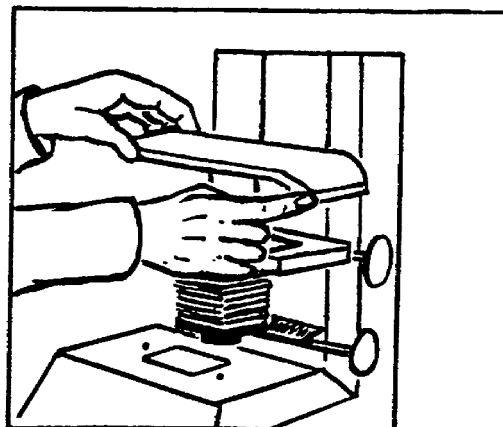


Figure 1-15. Removing Camera Back.

c. Pull out the rewind crank (figure 1-16). This will pull out the shaft inside the camera to make room for the film cassette.

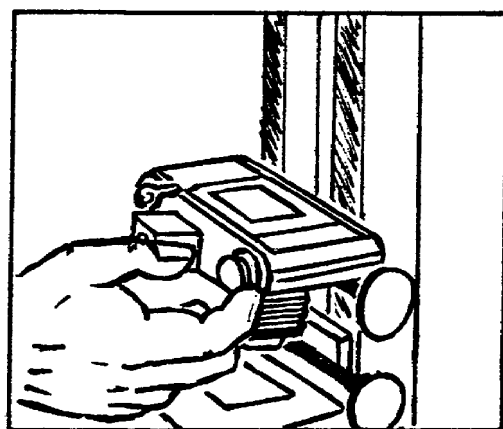


Figure 1-16. Pull Rewind Crank.





d. Hold a fresh roll of film with left thumb and index finger so that the film tab is inside your left palm (fig 1-17). Insert the cassette into the camera, while holding the film tab.

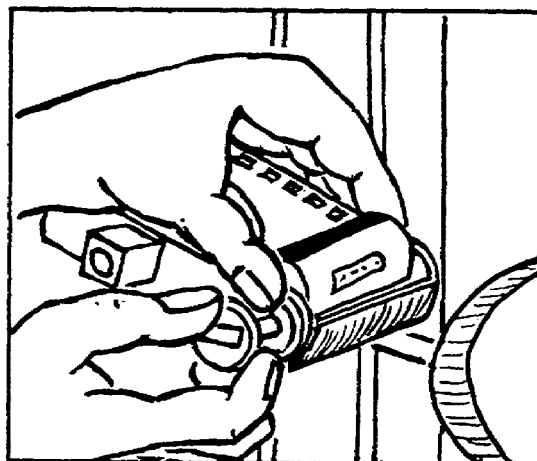


Figure 1-17. Insert Cassette.

e. After the cassette is placed in position, push the rewind (shaft) crank back into the original position (fig 1-18). While maintaining a slight pressure on the handle with your right hand, bring the film tab across to the left side.

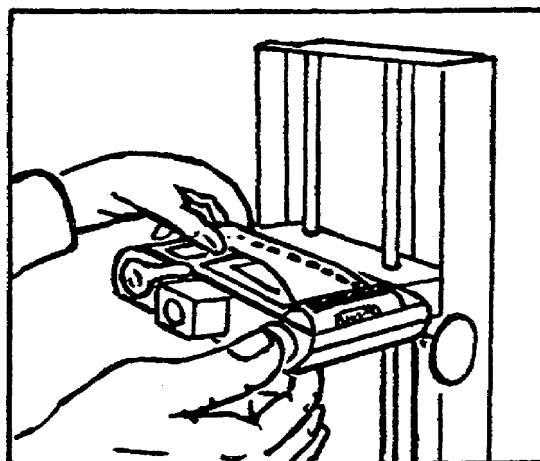


Figure 1-18. Push Rewind Crank.

f. Insert the film tab into one of the slots in the take-up spool, and at the same time, make sure that the film perforations are aligned with the sprockets in the camera to insure proper film advance (fig 1-19).

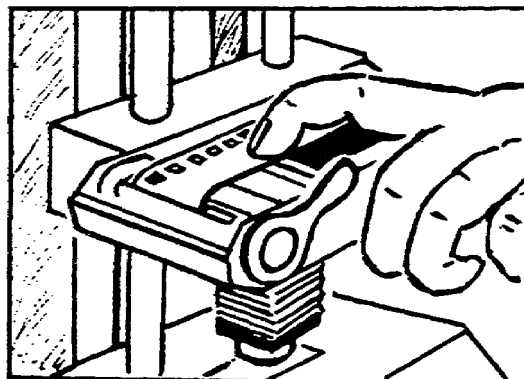


Figure 1-19. Insert Film Tab.



g. Once the film tab is inserted into the film take-up spool, and to visually insure proper film advance, turn the film advance lever to the right while holding the film cassette down with your right hand, (fig 1-20); this will insure proper tension on the film. Visually check the film advance during lever movement.

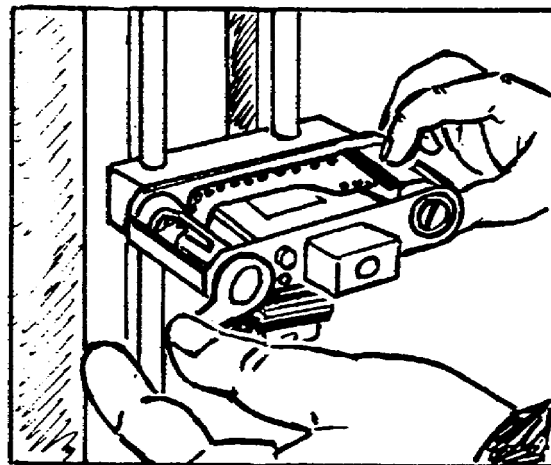


Figure 1-20. Turn Film Advance Lever.

h. After having insured that the film is properly threaded in the camera, take the camera back cover and reinsert it, left side first, into the camera, making sure that the cover sits correctly in the grooves (fig 1-21). Holding it in place with the left hand, carefully close it with the right hand. Make sure that the cover is COMPLETELY in place on the right side before closing the camera case latch, otherwise the camera will NOT be light tight and the film will become fogged from the outside.

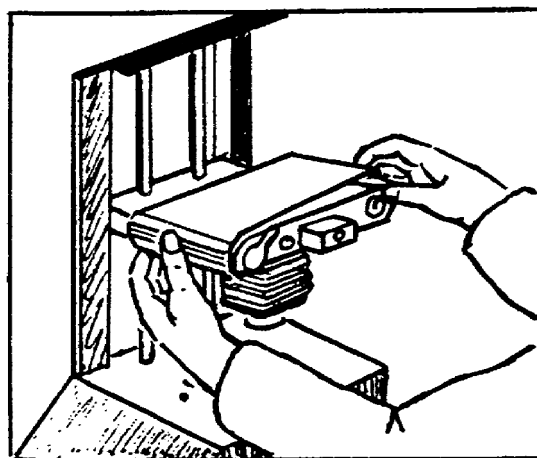


Figure 1-21. Replace Back Cover.



i. To unload the camera, you must first press the rewind button 1 - located to the left on the back of the camera (fig 1-22). Press the extension shaft and hold it down while, with the other hand, unfold the rewind crank handle and turn it in the direction indicated by the arrow on the handle until all the film has been wound back into the film cassette. Then open the camera back and remove the film cassette.

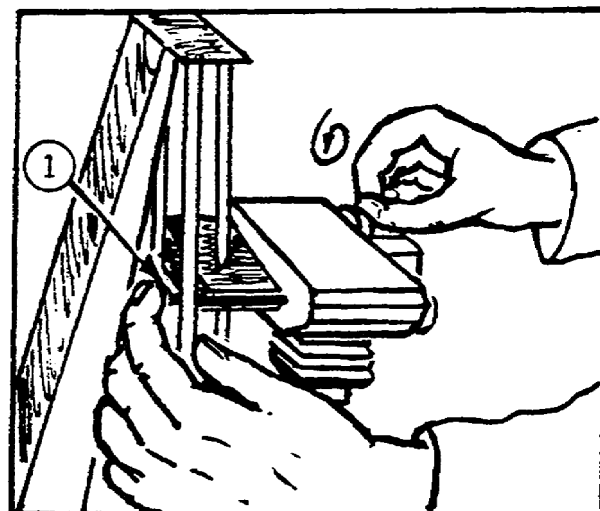


Figure 1-22. Unloading the Camera.

1-6. THE ELECTRONIC FLASH UNIT HOOK-UP. The synchronization cord for the flash unit is permanently attached to the copier base, but it is detachable at the camera. The proper connecting should be done in three simple steps. The camera synch cord connection is located on the right side of the camera body next to the lens bellows.

a. The camera connection is a bayonet connection with two small tabs (one on each side). First, line up the two slots in the cord with the two tabs on the camera connection (fig 1-23).

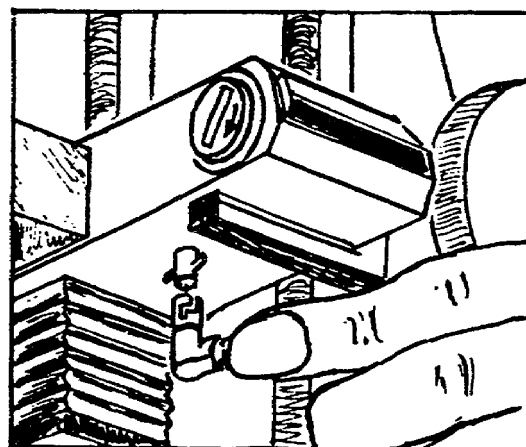


Figure 1-23. Sync Cord Connection.



b. Carefully place the cord connection onto the camera connection, making sure that the tabs are aligned and placed all the way in the cord receptacle (fig 1-24).

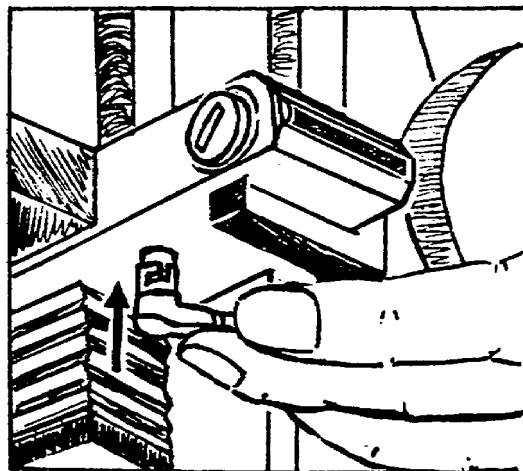


Figure 1-24. Attaching Sync Cord.

c. Next, push the cord connector completely onto the camera post. When it is all the way on, turn the cable connector clockwise. It is now locked in place (fig 1-25).

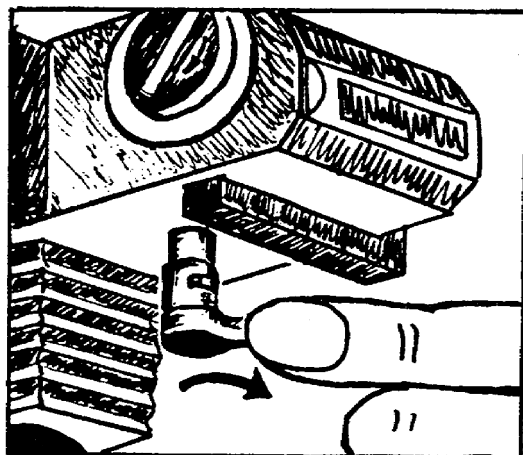


Figure 1-25. Locking Sync Cord.





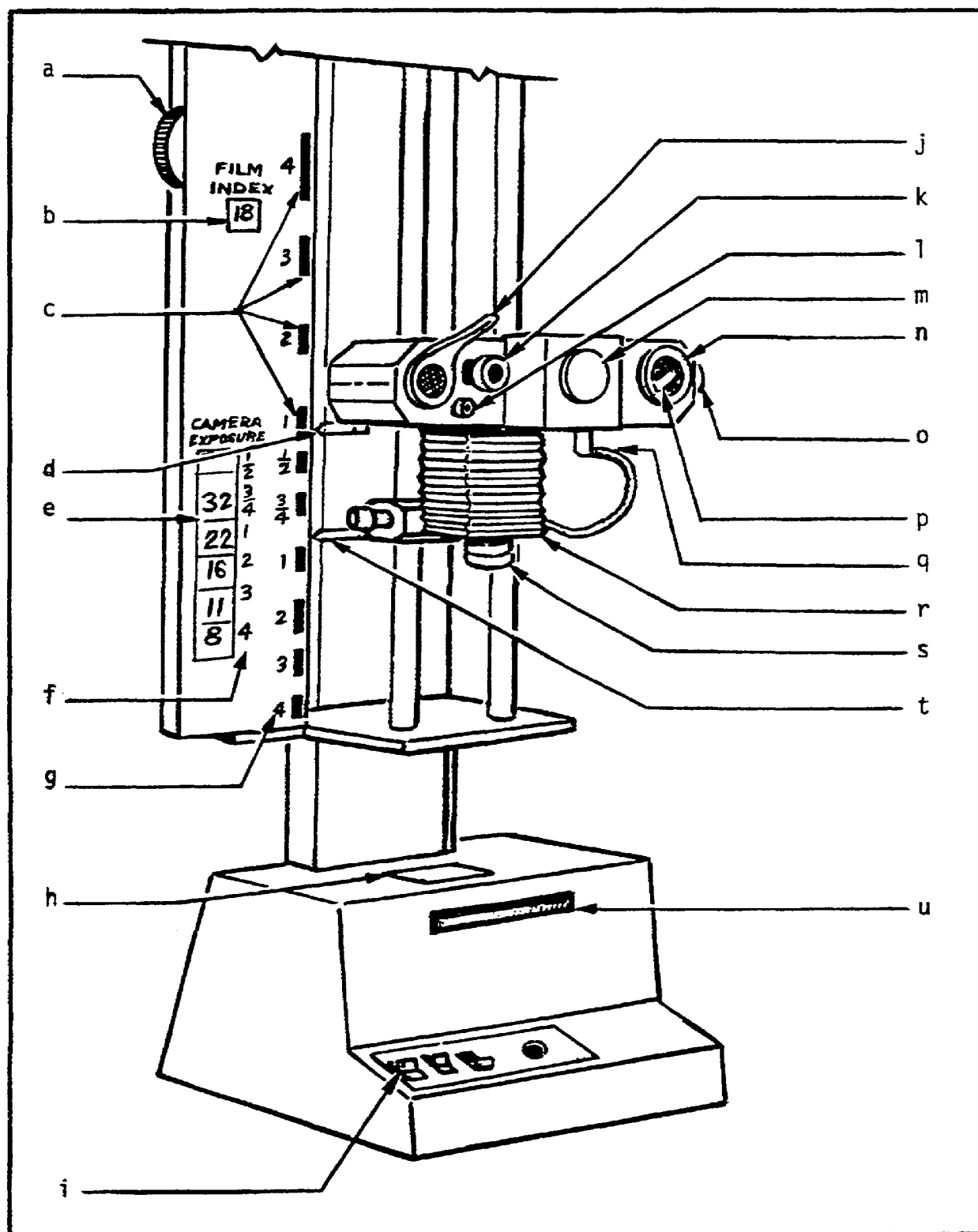
---

## REVIEW EXERCISE

12. What does the READY LIGHT indicate? \_\_\_\_\_  
\_\_\_\_\_
13. You have just turned the ON-OFF switch to ON, but nothing came on. You check to make sure that the REPRONAR is properly connected to the electrical outlet. What should you check next? \_\_\_\_\_  
\_\_\_\_\_
14. How much more light does the HIGH position on the HIGH-LOW switch provide than the LOW position? \_\_\_\_\_  
\_\_\_\_\_
15. You have just removed the camera back. What is the next step you must do before you can place the film cassette into the camera?  
\_\_\_\_\_
16. To insure proper film loading, you must make sure that the film perforations are aligned with the sprockets, and the film tab is properly seated into the take-up spool. (Circle one.)
- TRUE FALSE
17. What must you do to properly remove exposed (used) film from the camera?  
\_\_\_\_\_  
\_\_\_\_\_
18. List the steps to properly connect the sync cord.  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_



19. Fill in the blanks on pg 21 with the letter that shows the correct location in the illustration.



<u>LETTER</u>	<u>ITEM</u>
_____	Aperture selector pointer
_____	Aperture window
_____	Camera carriage pointer
_____	Camera case catch
_____	Camera aperture bar
_____	Control panel
_____	Crank for rewind
_____	Diaphragm ring
_____	Double exposure button
_____	Exposure calculator selector wheel
_____	Film index window
_____	Film reminder dial
_____	Film advance lever
_____	Filter compartment & holder
_____	Lens carriage pointer
_____	Magnifier
_____	Magnification scale-lower
_____	Magnification scale-upper
_____	Opal view glass
_____	Shutter knob
_____	Synchronizer cord



1-7. Up to now you have studied the functions of the 35mm REPRONAR SLIDE COPIER. You should have solved all exercises correctly, to include identification of the parts in the last illustration. You should now be familiar with the functions and operations of the REPRONAR. The REPRONAR is by no means the only 2x2-inch slide copier made. At this time it is the most common item being used by the military. You may be working with a different brand. The dials and controls may be in different places but the basic principles remain the same.

## SECTION III

### 4x5-INCH VIEW CAMERA

1-8. One of the most versatile camera systems in the medium format size is the 4x5-inch view camera. It can be used for closeup portraits, investigative, equipment reports, full lengths, and copy photography. One of the main reasons it is so commonly used is that you obtain a negative which is big enough to make substantial enlargements and yet small enough to use standard darkroom equipment. This format is also easy to retouch and handle with little fear of scratching the negative. It must, however, be used on a tripod.

a. The 4x5 view camera functions a little differently from your average camera (fig 1-26). Some of the differences are:

- (1) Movable front and rear frame.
- (2) Movable front and rear carriage.
- (3) Swing and tilting front and rear carriage.
- (4) Front and rear focusing.

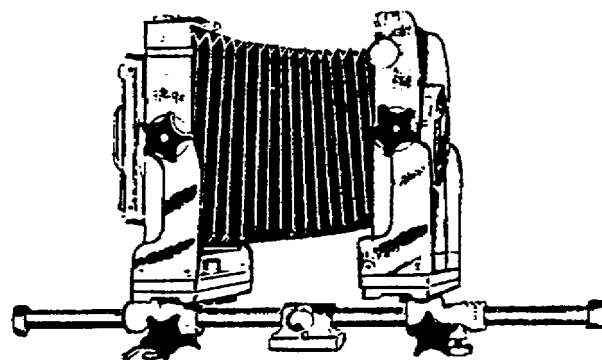


Figure 1-26. 4x5-inch View Camera.





## 1-9. CAMERA FUNCTIONS.

a. First we will identify all the movable parts of the 4x5-inch view camera and describe their functions (fig's 1-27, 1-28 and 1-29):

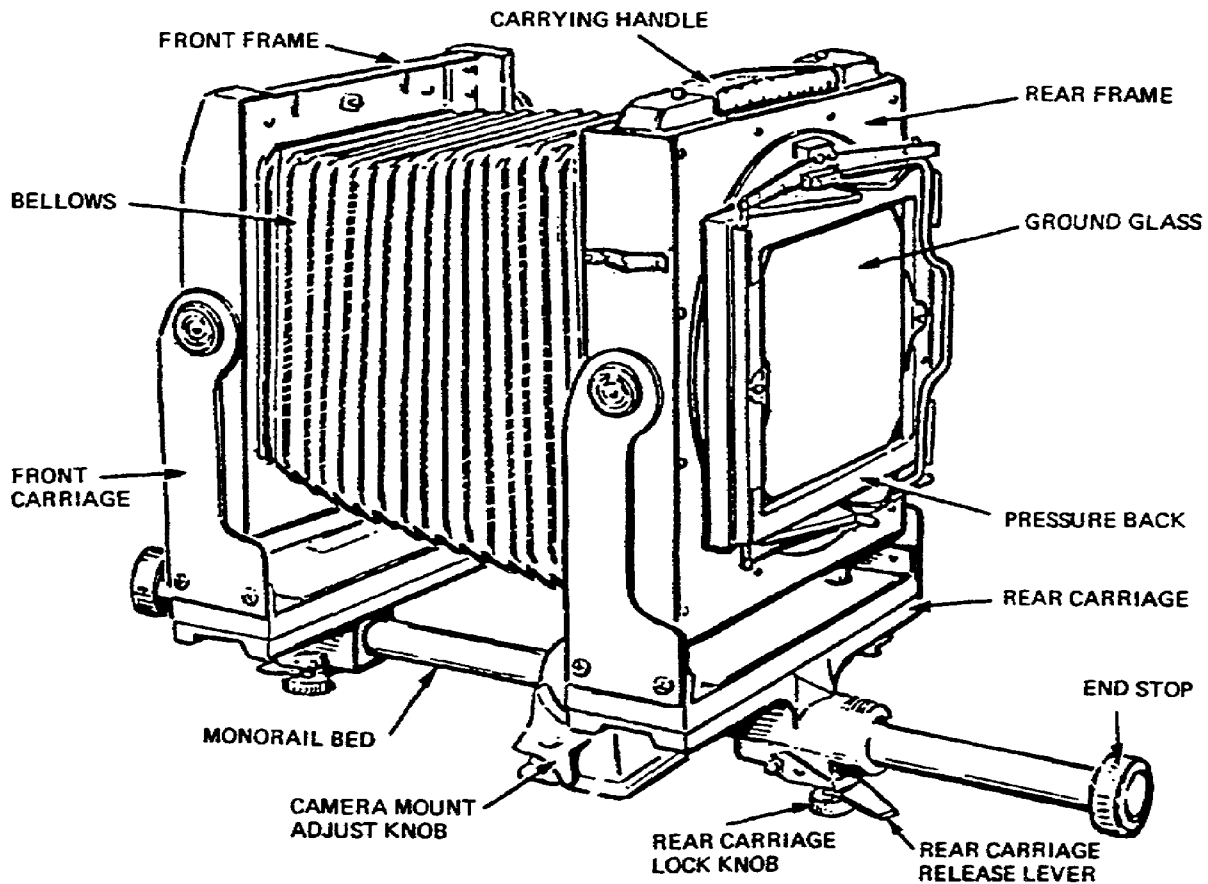


Figure 1-27. 4x5-inch view camera (rear-side view)

- (1) Camera mount adjust knob - positions camera mount on monorail bed.
- (2) Rear carriage lock knob - locks rear carriage on monorail bed. When loosened, permits rear carriage to slide on monorail bed.
- (3) Rear carriage release lever - when raised, permits rapid sliding of rear carriage along monorail bed.
- (4) Rear carriage - holds rear frame.
- (5) Pressure back - holds film holder.
- (6) Rear frame - tilts and holds rotating back, ground glass and pressure back.
- (7) Front frame - tilts and holds lens board.



- (8) Front carriage lock knob - locks front carriage on monorail bed. When loosened, permits front carriage to slide on monorail.
- (9) Front carriage adjust knob - adjusts position of front carriage on monorail bed.
- (10) Front carriage release lever - when raised, permits rapid sliding of front carriage on monorail bed.
- (11) Front pivot lock knob - locks front frame in degree of vertical tilt selected. When loosened, permits change in degree of tilt.
- (12) Lens board retainer (Slidelock) - secures lens board to lens board mounting plate.
- (13) Pinion knob - raises and lowers lens board mounting plate.
- (14) Rear carriage adjust knob - positions rear carriage on monorail bed.

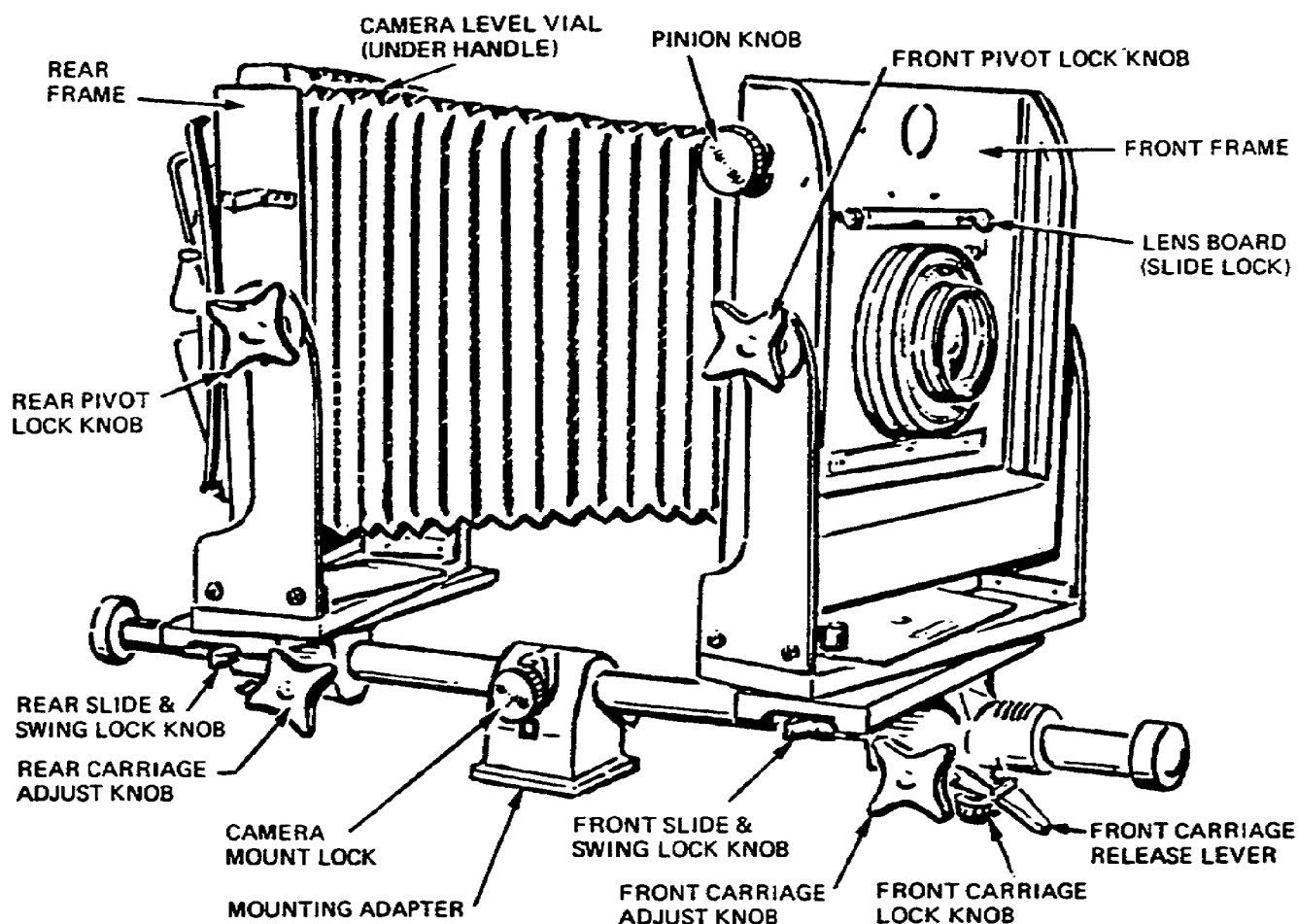


Figure 1-28. 4x5-inch camera (front-side view).



(15) Rear pivot lock knob - locks rear frame at degree of vertical tilt selected. When loosened, permits change in degree of vertical tilt.

(16) Camera mount lock - locks camera mount on monorail bed. When loosened, permits change of camera position on monorail bed.

(17) Front side and swing lock knob- locks front frame in position on front carriage. When loosened, permits swinging and/or sliding of front frame on front carriage.

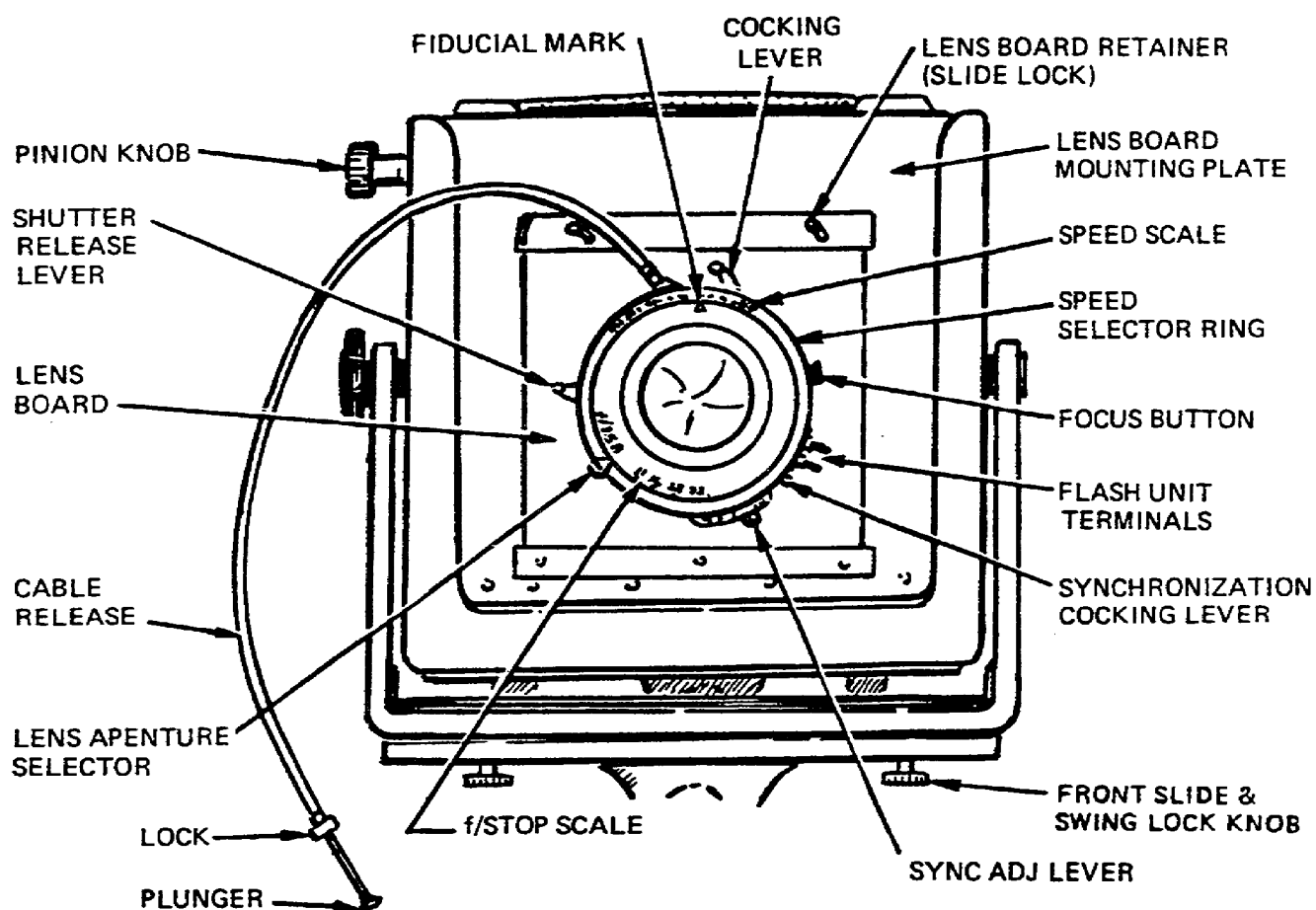


Figure 1-29. 4x5-inch view camera (front view).



- (18) Speed selector ring - sets shutter speed exposure timing.
- (19) Lens aperture selector - sets diameter of lens opening (f/stop).
- (20) Cocking lever - sets up shutter for tripping by tensioning activating spring.
- (21) Focus button - opens cocked shutter for focusing.
- (22) Release lever - trips shutter actuating mechanism.
- (23) Synchronism adjustment- adjusts internal shutter synchronization delay for flashlamp and electronic flash use.
- (24) Synchronization cocking lever- sets up shutter synchronizing for operation. (This lever is not found on newer models.)

b. Lens indicators.

- (1) Speed scale- indicates length of time (in seconds) shutter will remain open during an exposure.
- (2) Fiducial mark - indicates effective shutter speed setting.
- (3) f/Stop scale - indicates relative diameter of lens opening (f/stop opening) with respect to lens focal length.
- (4) Synchronism adjustment lever – indicates effective synchronism contact closing before shutter reaches maximum opening.

Synch Setting

Milliseconds Delay

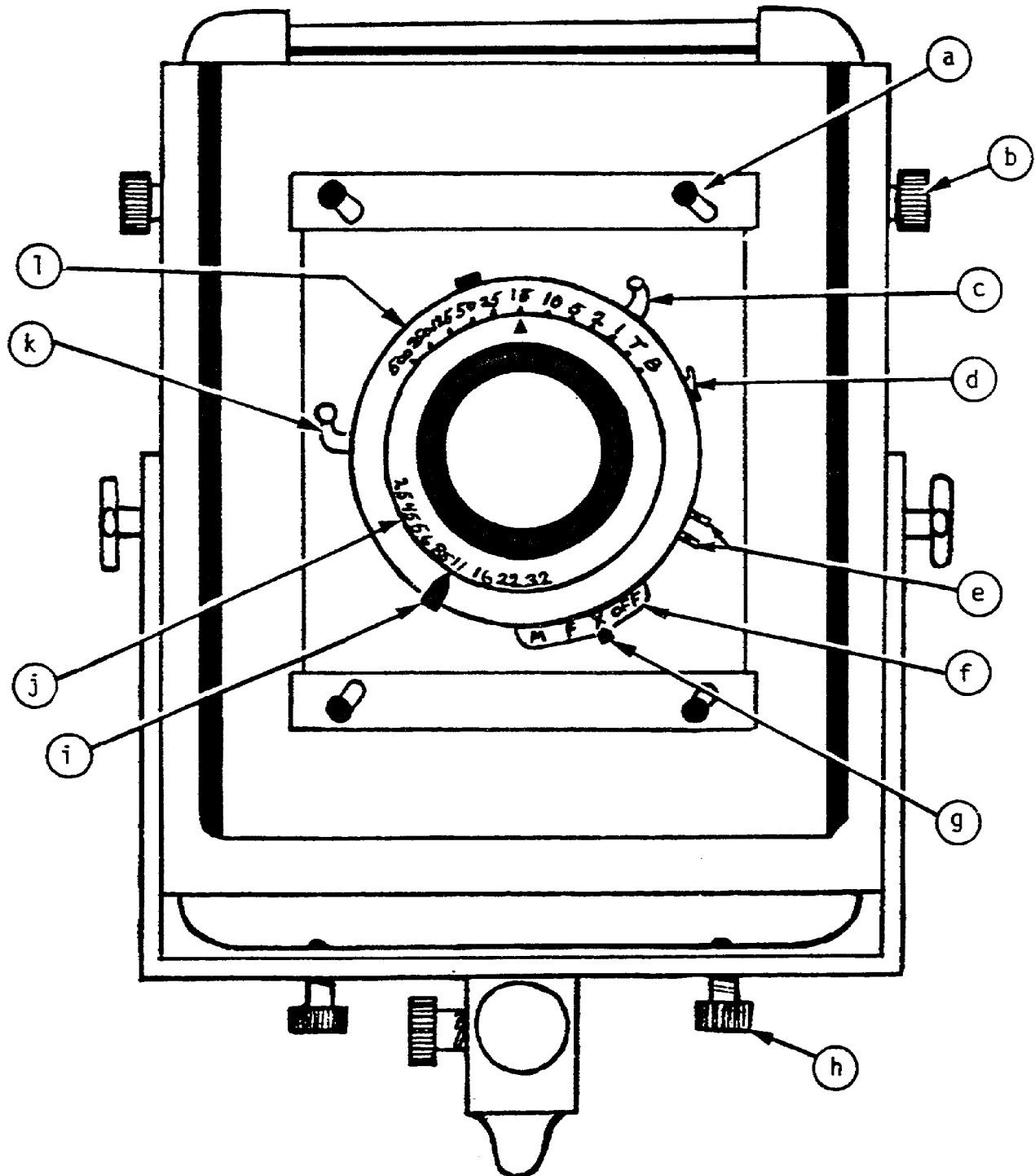
M	20
F	5
X	0
OFF	OFF





REVIEW EXERCISE

20. Fill in the blanks on page 28 with the letter that shows the correct location in the illustration below.



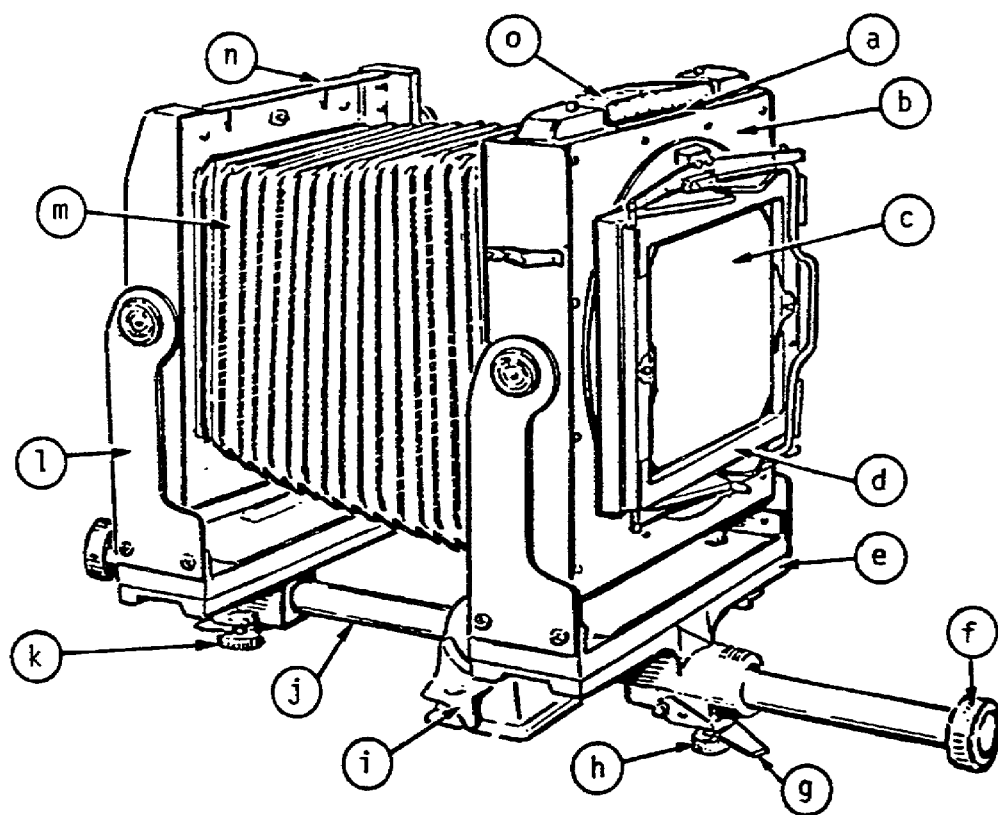


<u>ITEM</u>	<u>LETTER</u>	<u>ITEM</u>	<u>LETTER</u>
Cocking lever	_____	Lens board retainer	_____
Focus button	_____	Flash unit terminals	_____
Front slide and Swing lock knob	_____	Synchronism selector lever	_____
Pinion knob	_____	f/Stop scale	_____
Synchronism adjustment	_____	Lens aperture selector	_____
Speed selector ring	_____	Shutter release lever	_____

21. Fill in the blanks below with the letter that shows the correct location in the illustration on the next page.

<u>ITEM</u>	<u>LETTER</u>	<u>ITEM</u>	<u>LETTER</u>
Camera level vial	_____	Rear carriage	_____
Front carriage	_____	Camera mount adjust knob	_____
End stop	_____	Front carriage lock knob	_____
Carrying handle	_____	Monorail bed	_____
Rear frame	_____	Rear carriage release lever	_____
Bellows	_____	Rear carriage lock knob	_____
Pressure back	_____	Ground glass	_____
Front frame	_____		







1-10. Up to this point we have talked about and identified the various parts of the 4x5-inch view camera and their functions. Now let's discuss how to prepare your cut-film holder and film pack adapter. Both are 4x5-inches in size.

a. Load the cut-film holders preferably in a photographic darkroom. Any room or space which completely blocks out all light may be used. Panchromatic film must be handled in total darkness. Other films may be handled in a darkroom equipped with a recommended safelight (follow manufacturer's instructions).

b. We will talk you through step by step on how to load your film. Study fig 1-30 first, then read on and you will be able to load your film correctly. REMEMBER, it MUST be done in TOTAL DARKNESS.

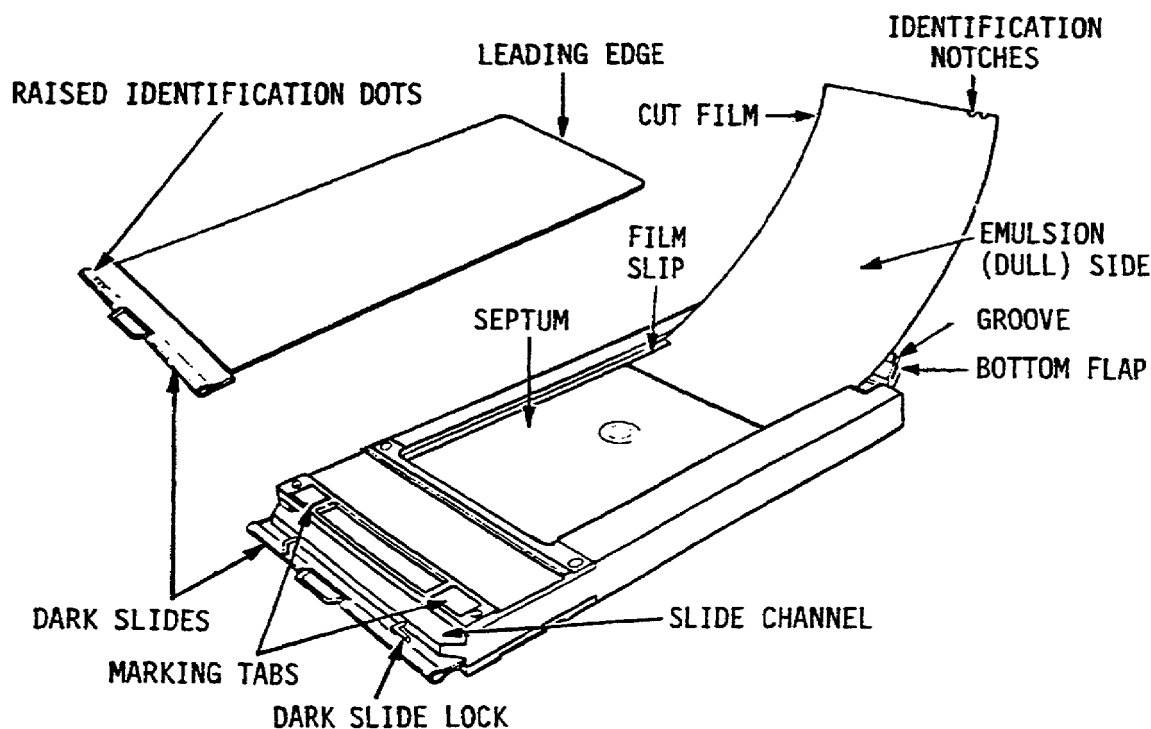


Figure 1-30. Cut Film Holder.





- (1) Withdraw the dark slide from the cut-film holder.
- (2) Swing the bottom flap out to open the bottom of the cut-film holder.
- (3) Grasp a sheet of cut-film by the edges so that the emulsion (dull) side is up and the identification notches are in the upper right hand corner (fig 1-31).

**NOTE:** The identification notches may be felt with the right index finger when the unnotched shorter edge is toward the operator.

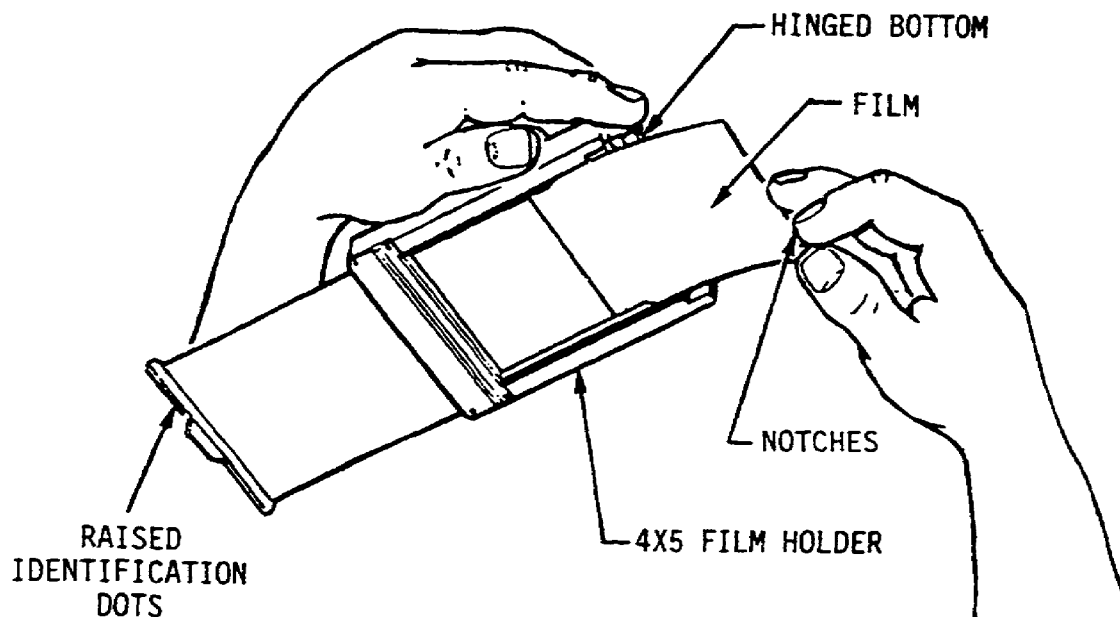


Figure 1-31. Loading Cut Film Holder.



- (4) Slip the corners of the unnotched shorter edge of the cut-film under the film slips (along each long side of the septum) and slide the film completely into the holder.
- (5) Swing the bottom flap closed and hold down firmly.
- (6) Insert the dark slide into the slide channel so that the raised identification dots face up and away from the cut-film holder.
- (7) Push the dark slide all the way into the cut-film holder; make sure the end of the leading edge of the dark slide engages the groove along the edge of the bottom flap.
- (8) Turn the slide hook over the end of the dark slide to prevent accidental removal of the dark slide.
- (9) Load the reverse side of the cut-film holder by repeating the procedures in (1) through (8) above.
- (10) Load additional cut-film holders by repeating the procedures in (1) through (9) above.

c. Loading film pack adapter (fig 1-32). The film pack adapter may be loaded under existing lighting conditions. DO NOT expose the film pack to direct sunlight during loading.

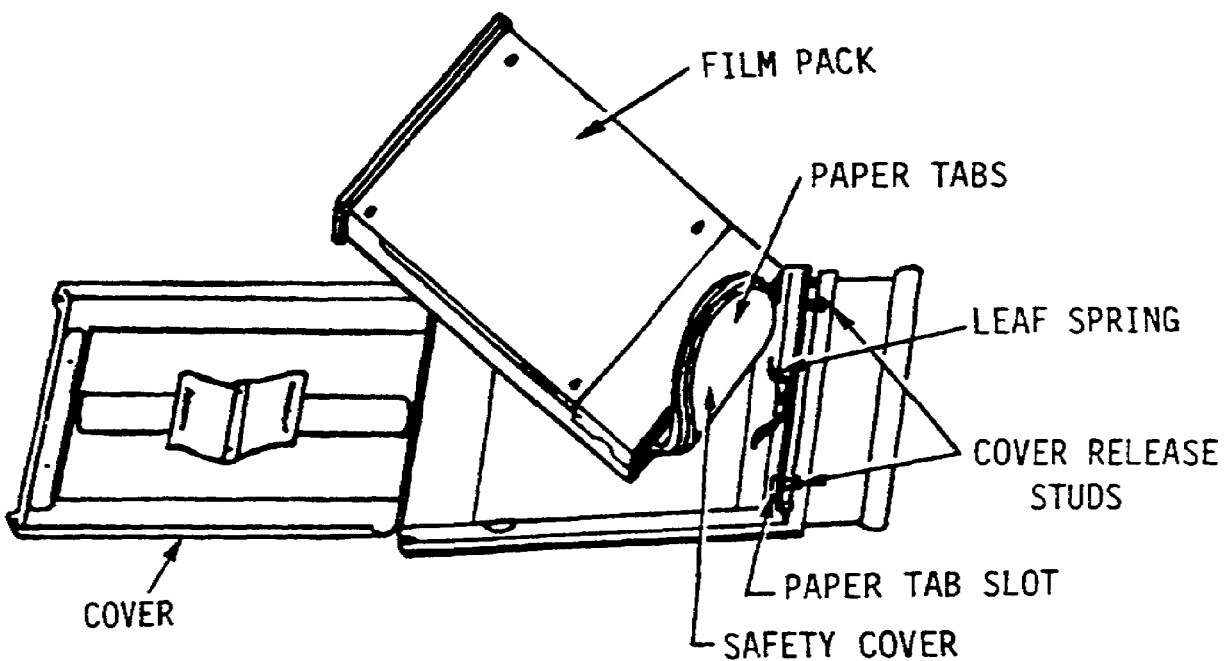


Figure 1-32. Film Pack Adapter.



- (1) Make sure the dark slide is inserted into the film pack adapter before attempting to load.
- (2) Simultaneously press the two cover release studs to open the cover.
- (3) Unwrap the film pack and insert the film into the adapter, as shown.

**CAUTION:** Hold the film pack carefully by the sides. Do not depress the black safety paper cover or twist the metal frame; to do so may cause light to enter the film pack.

- (4) Make sure that the film pack is inserted into the film pack adapter with the paper safety cover facing the dark slide, and that all the paper tabs rest in the paper tab slot.
- (5) Push the pack against the spring and drop into place.
- (6) Close the cover, making sure it latches and that all paper tabs are centered in the paper tab slot and moves freely.
- (7) Pull out the safety cover tab to its stop (about 5 inches) and tear it off. REMEMBER, make sure that the dark slide is inserted into the film pack adapted.

---

## REVIEW EXERCISE

22. To indicate there is unexposed film in a loaded 4x5-inch cut-film holder, the film holder dark slide must be inserted so that the RAISED IDENTIFICATION DOTS are facing

\_\_\_\_\_  
(fill-in)

23. How can you be sure that the emulsion side is facing up when you are loading sheet film into a film holder?

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_



24. When loading a fresh film pack into a film pack adapter, you must always make sure that \_\_\_\_\_ (fill in)

d. Up to this point we have discussed the 4x5-inch view camera and identified all the various moving parts. We have talked about the 4x5-inch cut-film and film pack, how to load each one and how to make them ready for use. But before you get down to the business of using the camera and the film together, we need to talk about the specific parts and procedures of the camera which are necessary to properly perform a photographic function.

# 1-11. 4x5-INCH VIEW CAMERA FUNCTION.

a. Coarse focusing procedure. This is done in the following manner.

(1) To open the lens, do the following steps (fig 1-33):

(a) Set the lens opening selector 1 to the smallest f/number (widest aperture) on the f/stop scale to provide maximum lens opening during focusing.

(b) Depress the cocking lever 2 to cock the shutter.

(c) Depress the focus button 3 to open the lens.

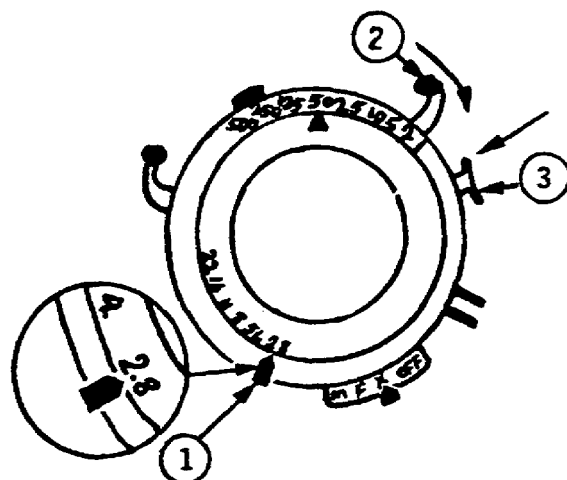


Figure 1-33.  
Coarse Focusing.

(2) Next you loosen the front and rear carriage lock knobs 1 (fig 1-34) enough to allow the front and rear carriages to slide on the monorail bed when the front and rear carriage adjust knobs 2 are rotated.





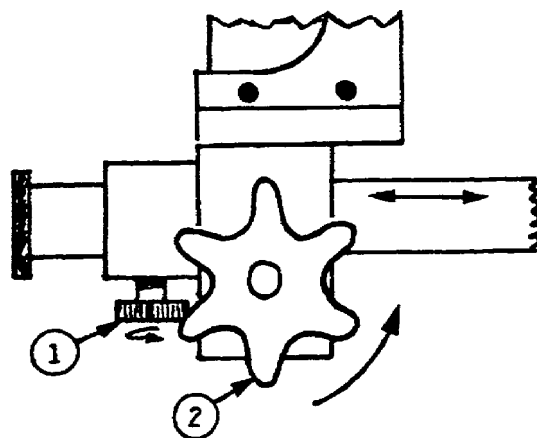


Figure 1-34. Carriage Knobs.

(4) To produce the desired image on the ground glass, the height, angle, and direction of the camera may have to be changed. Use the tripod controls as outlined below:

- (a) To initially adjust the camera height, loosen the leg thumbscrews and extend or retract the telescoping legs as required; tighten leg thumbscrews securely after height adjustment is made.
- (b) For additional height adjustment, loosen the center lock post knob and slide the center post up or down as required. After obtaining the desired height adjustment, tighten the center post lock knob securely.

**CAUTION:** Always maintain a firm grip on the tripod control handle when loosening the tilt lock knob. Unless the camera is accurately balanced on the panhead, rapid tilting will occur, with possible damage to camera or tripod.

- (c) To adjust the degree of camera tilt, loosen the tilt lock knob and, with the tripod control handle, tilt the camera to the desired angle. After obtaining the desired tilt adjustment, tighten the tilt lock knob securely.
- (d) To change the rotational position of the camera, loosen the rotation lock knob and with the



tripod control handle, rotate the camera to the desired angle; tighten the rotation lock knob securely after rotational adjustment is made.

b. Fine focusing procedure. The camera has provisions for raising, falling, swinging, and sliding tilts that can change the lens axis and film plane with respect to each other.

**NOTE:** The rising, falling, swinging, and sliding tilts provided on the camera exceed the covering power of the lens and shutter assemblies supplied. Be careful, when composing the subject on the ground glass, not to exceed the covering power of the lens and shutter assembly in use to avoid cutoff at the corners.

(1) To eliminate undesirable foreground or background from the photograph, or to eliminate wasted space at the top or bottom of image, raise or lower the lens board mounting plate by pushing in and rotating the spring-loaded pinion knob 1 (fig 1-35), until the desired degree of elimination is achieved.

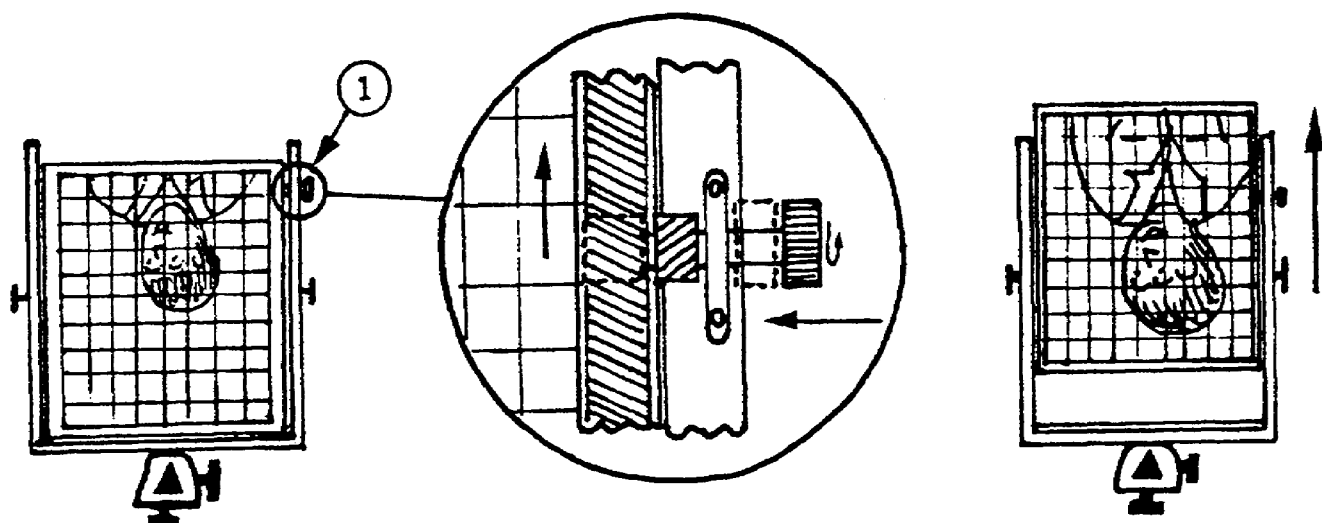


Figure 1-35. Image placement.

(2) After approximate focus has been obtained, slight changes in the image size on the ground glass may be obtained by moving the monorail bed with respect to the panhead, as follows:



- (a) Loosen the camera mount lock 1 (fig 1-36) and turn the camera mount adjust knob.
- (b) After positioning the camera with respect to the subject, tighten the camera mount lock 1 .

**NOTE:** Since the front and rear carriages are secured to the monorail bed, the distance between the front and rear carriage is not changed by the rotating camera mount adjust knob. In fig 1-36,  $D$  is the subject to camera distance and  $FL$  is the camera focal length.

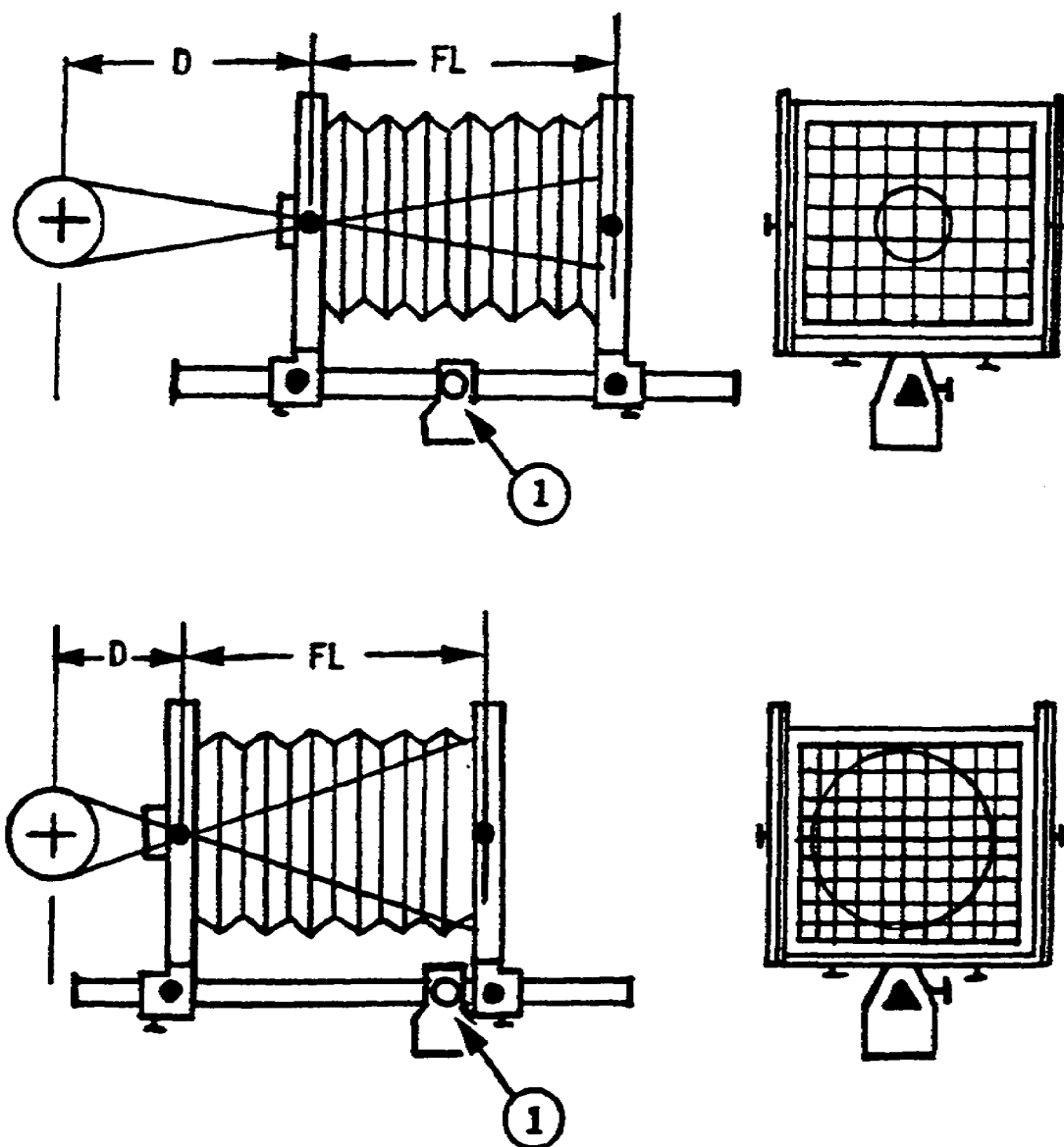


Figure 1-36. Changing Image Size.

(3) When the camera cannot be centered horizontally with respect to the subject because of an obstruction, centering of the subject on the ground glass may be obtained by sliding the front or rear frame, or both, with respect to its carriage. Slide the front or rear frame as follows:

(a) Loosen the respective slide and swing lock knob 1, (fig 1-37).

(b) Gently slide the front or rear frame to the right or left, as desired, on its respective carriage.

(c) After adjustment is made, tighten the respective slide and swing lock knob 1.

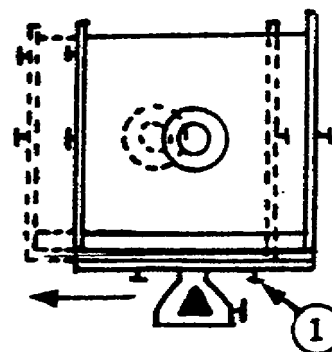


Figure 1-37. Sliding Frame.

**NOTE:** The following camera controls are used for 3 dimensional subjects. They normally are not required for copy photography. However, these controls are available on the camera and in certain circumstances may be required.

(4) To place the plane of sharp focus of the lens in the most advantageous relationship to the subject, use the swings and tilts of the front frame. Tilt the camera front frame as follows:

(a) Loosen the front pivot lock knob 2, (fig 1-38).

(b) Tilt the front frame forward or backward to the angle desired.

(c) After the tilting adjustment is made, tighten the front pivot lock knob 2.

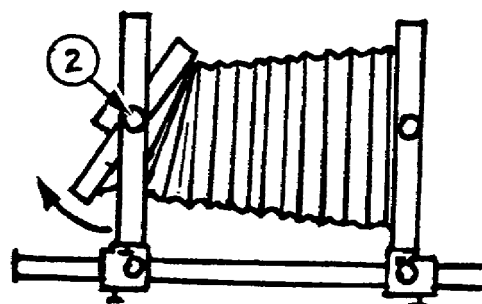


Figure 1-38. Pivot Lock Knob.



(d) Loosen the front slide and swing lock knob 1, (fig 1-39).

(e) Grasp the front frame near the base and rotate it on the front carriage to the desired angle.

(f) After positioning the front frame, tighten the front slide and swing lock knob 1 securely.

(5) The rear frame has similar swinging and tilting provisions to permit correction for converging and diverging horizontal and vertical lines. The method of adjusting the rear frame is the same as described in 4a, b, c, d, e, and f above, except that the rear controls are used, (fig 1-40).

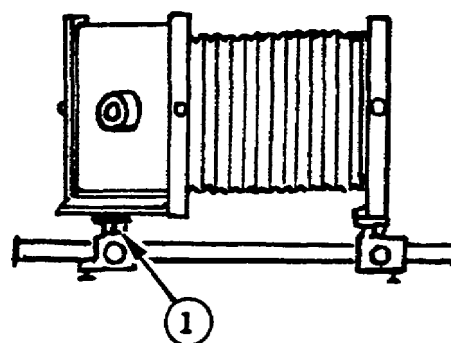


Figure 1-39. Front Slide Knob.

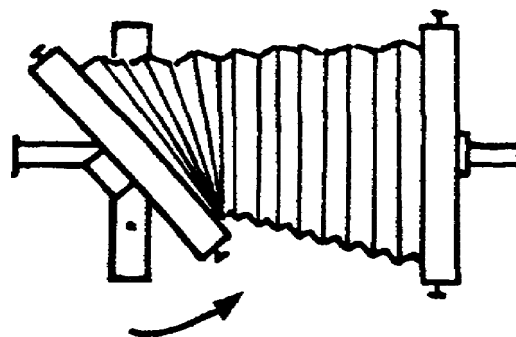


Figure 1-40. Rear Frame Swing.

**NOTE:** Detents are provided to indicate when the front and rear frames are in the normal perpendicular and swing positions with respect to the monorail bed.

(6) Changes in the orientation of the subject, with respect to the long and short dimensions of the film, may be made by rotating the camera back. Rotation of the back also permits more advantageous use of the film area when photographing long narrow subjects. The back can be rotated in either direction and locked in place. Rotate the back as follows:





(a) Lift the two ground glass clips 1 , (fig 1-41), up to let free the two tips on the ground glass frame.

(b) Lift the ground glass frame off the camera area frame and rotate it either right or left.

(c) Place the ground glass frame back on the rear camera frame, placing the bottom edge in first, then lightly push the top edge until the two ground glass tips snap into place under the two ground glass clips 1 .

○

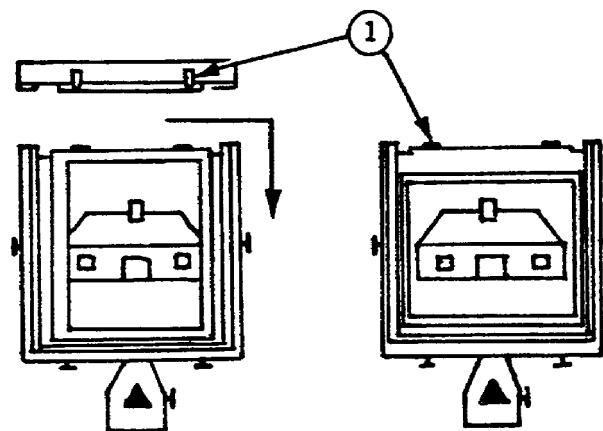


Figure 1-41. Ground Glass Clips.

(7) Lens and shutter assembly adjustment.

(a) After completing the focusing procedures (para a and b), depress the shutter release lever 1 , (fig 1-42), to close the shutter.

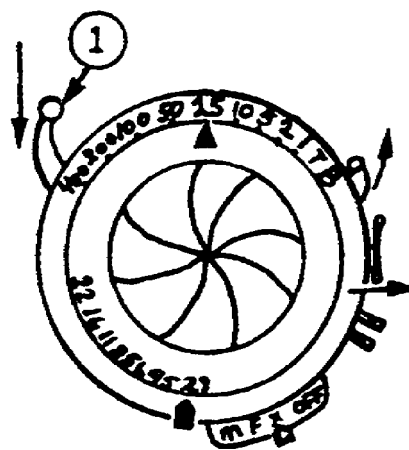


Figure 1-42. Shutter Release Lever.







(8) Inserting cut-film or film pack adapter. The spring-loaded focusing frame is attached to the camera back with the camera back release spring, which allows you to insert the cut-film holder and film pack adapter into the camera as follows (fig 1-45):

(a) Hold the focusing frame assembly (camera back) away from the camera body by using the two fingerpads.

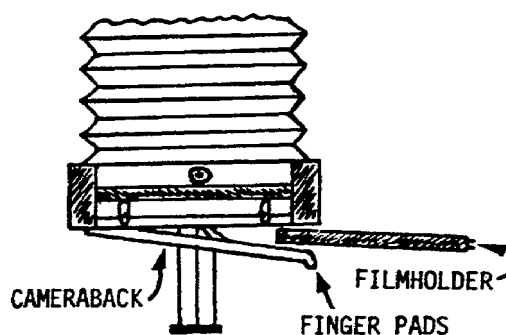


Figure 1-45. Inserting Holder.

(b) Slide the film holder into the camera between the focusing frame assembly and the camera body as far as it will go.

(c) Check to be sure that the silver side of the dark slide is facing the lens, indicating that the film is unexposed.

(d) Press the shutter cocking lever to cock shutter actuating mechanism.

(e) Carefully pull out the dark slide from the cut-film holder.

(f) Depress the shutter release lever, or the plunger on the cable release, to make an exposure.

**NOTE:** With the fiducial mark on the speed ring set opposite a number on the speed scale, the shutter opens and closes with one operation of the cable release or release lever. With fiducial mark set at B (bulb), the shutter opens when the cable release is operated and closes when the cable release plunger is released. If an opening of several seconds is required, finger tighten the lock on the cable release to hold the shutter open. With the fiducial mark set at T (time), two operations of the cable release, or the release lever, are required; the first opens the shutter and the second operation closes the shutter.



(9) Carefully return the dark slide to position in the cut-film holder. Assure that the black side of the dark slide handle is outward to indicate the film in the cut-film holder is exposed. Turn the dark slide lock over the end of the dark slide handle to prevent re-exposure or accidental removal of the dark slide.

(10) Pull back the focusing frame assembly and remove the cut-film holder from the camera.

(11) Turn the cut-film holder over and reinsert it in the camera.

(12) Expose the film in the remaining side of the cut-film holder by repeating the procedures in (8) through (10) above.

---

## REVIEW EXERCISE

25. List the steps you must do in order to open the lens, before you can focus the 4x5-inch view camera.

---

---

---

26. You have just loosened the front and rear carriage lock knobs. You are now ready to \_\_\_\_\_

(fill in)

27. You have just set up your camera and mounted it on a tripod, but it is about 5 to 6 inches too low to be centered on the subject. Which step should you take to adjust the difference without moving the subject to be copied?

---

---

28. How do you adjust camera tilt? \_\_\_\_\_

---

---





29. You have made all possible adjustments to correct your image on the ground glass, but it still is not framed correctly to get maximum use of the film area. There is still some wasted space at the top of your image. What must you do to correct this? \_\_\_\_\_

\_\_\_\_\_.

30. What must you do to increase the image size without changing the camera focal length? \_\_\_\_\_

\_\_\_\_\_.

31. If your camera is not centered horizontally, with respect to your subject, what adjustment can you make?

\_\_\_\_\_.

32. If you want to tilt the lens up or down, what lock knob must be used?

\_\_\_\_\_.

33. You have just finished fine focusing your image on the ground glass. The image to be photographed is too wide for the vertical format, and there will be some unused film area at the top and bottom on the ground glass. How can you correct for this without moving or changing the camera lens?

\_\_\_\_\_.

34. You have just inserted a loaded film holder into the camera and cocked the shutter. Your f/stop and shutter speed are already set. What is the last thing you must do before you make the exposure?

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_.



1-12. You should be familiar enough with the various functions of the 4x5-inch view camera, that you can operate it properly in order to get the best results when you do copy work.

## SECTION IV

### 8x10-INCH COPY CAMERA FUNCTION

#### 1-13. INTRODUCTION:

The 8x10-inch copy camera KS-7A, is a studio-type camera that can be operated in either the vertical or the horizontal position. The 8x10-inch camera is used for copying photographs, line drawings, and other flat copy; or, for making enlargements, reductions, and photographs of bulky objects.

1-14. DESCRIPTION OF CAMERA. We will first identify the major components and then we will talk about the functions of each of the major components, (fig 1-46). The camera consists of a camera body, two carriages, a 4x5 focusing back, an 8x10 focusing back, two front movement mechanisms, two handwheel assemblies, a camera bed, and an easel.

a. Camera body. The camera body includes the following:

(1) A front frame for mounting the lens assembly. The front frame contains a front stationary plate and two front movement plates (horizontal and vertical).

(2) A front bellows and a rear bellows, which provide a flexible light-tight compartment (body).

(3) A center frame for securing the bellows in the center of the camera body.

(4) A rear frame for mounting the focusing backs. A clip at each corner of the rear frame provides the means for securing the focusing back to the rear frame.

b. Carriages. The front and rear carriages are castings that are secured to the front and rear frames respectively. The carriages house the camera movement and locking mechanisms and the slides that slide on the tubular guide bars.



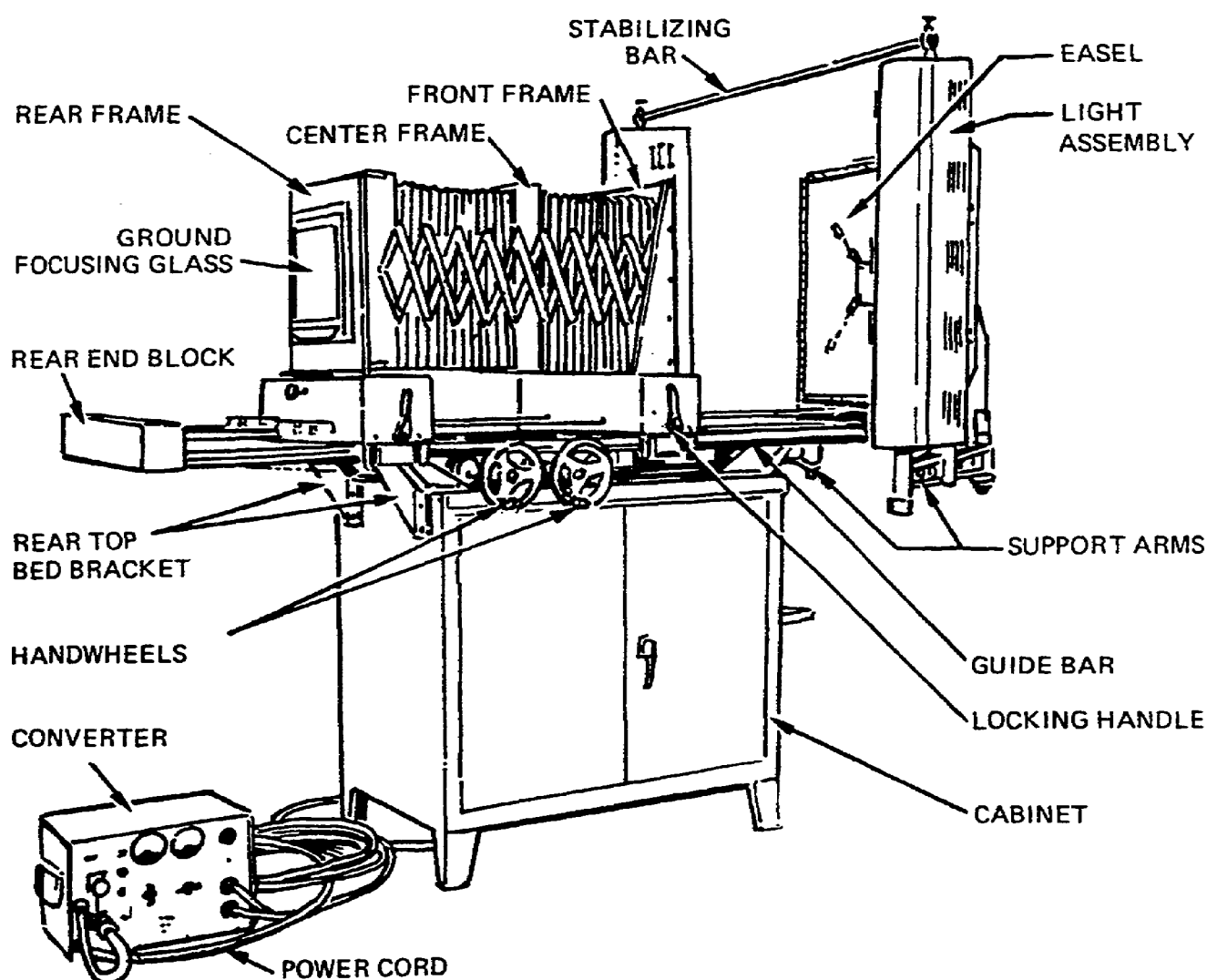


Figure 1-46. 8x10-inch Copy Camera, KS-7A.

c. Camera focusing backs. Two focusing backs are provided with the camera set.

(1) 4x5-inch focusing back. The 4x5-inch focusing back is interchangeable with the 8x10-inch focusing back ((2) below). The focusing panel shield is secured within the focusing back by two springs. A ground focusing glass is mounted within the focusing panel shield. Horizontal and vertical lines on the ground focusing glass provide a scale to align the image.

(2) 8x10-inch focusing back. The 8x10-inch focusing back is interchangeable with the 4x5-inch focusing back ((1) above). The focusing panel shield is secured within the focusing back by a screw in each corner. A ground focusing glass is mounted within the focusing panel shield. Horizontal and vertical lines on the ground focusing glass provide a scale to align the image.

d. Front movement mechanisms. The front movement mechanisms provide the facilities for horizontal movement or for vertical movement of the lens assembly. Each mechanism consists of a guide bar that runs the full length of the carriage bed, a handle grip, and a gear arrangement. (fig 1-47).

e. Handwheel assemblies. Two handwheel assemblies are provided for movement of the camera carriages. The handwheels (front and rear), through a system of cable reels and wire ropes, move the camera carriages forward and backward as required. They are used to focus and adjust the distance between front and rear carriages.

f. Camera bed. The camera bed includes two tubular guide rails with an end block at each end. Wire rope pulleys are secured to brackets within the end blocks. Two connecting bars between the tubular guide rails provide additional rigidity for the camera bed.

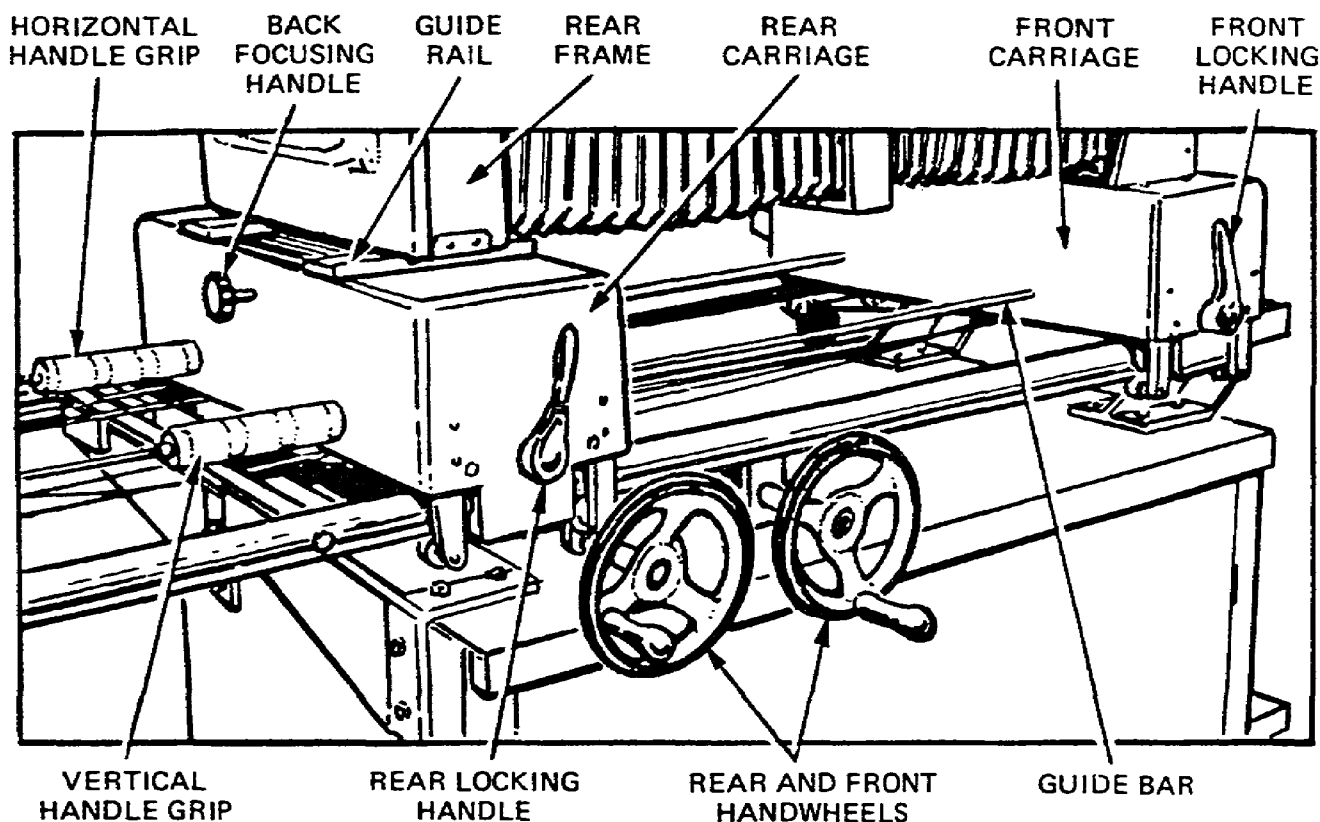


Figure 1-47. Camera Controls, partial view.





g. Easel. The easel is hinge mounted on the front end and includes an opal glass secured within the easel frame. This is used when copying transparent material, by placing an illuminating light source behind the easel. Five interlocking photographic masks, (fig 1-48), are supplied to hold copy to the glass frame. Both the glass frame and the masks use clips to secure copy, or the next smaller mask, to the easel. A calibrated mounting plate ((2) below) mounted on a sponge rubber padded mounting board, and two glass plates, are also part of the easel.

h. Masks. Five standard size interlocking masks, ranging in size from  $3\frac{1}{4}$ x4-inches, 4x5-inches, 5x7-inches, 8x10-inches to 11x14-inches, are used to exclude extraneous light from the camera lens. The large mask can be used by itself to frame an object on the easel. When a smaller mask is used, however, it must be mounted within the next largest mask. Thus, when the smallest mask ( $3\frac{1}{4}$ x4-inch) is used, all masks must be mounted on the easel.

(1) Mounting plate. The mounting plate is used to provide copy support on the easel. The mounting plate has a white imprinted scale calibrated in inches, and a border imprinted for  $8\frac{1}{2}$ x11-inch and  $8\frac{1}{2}$ x14-inch sheets.



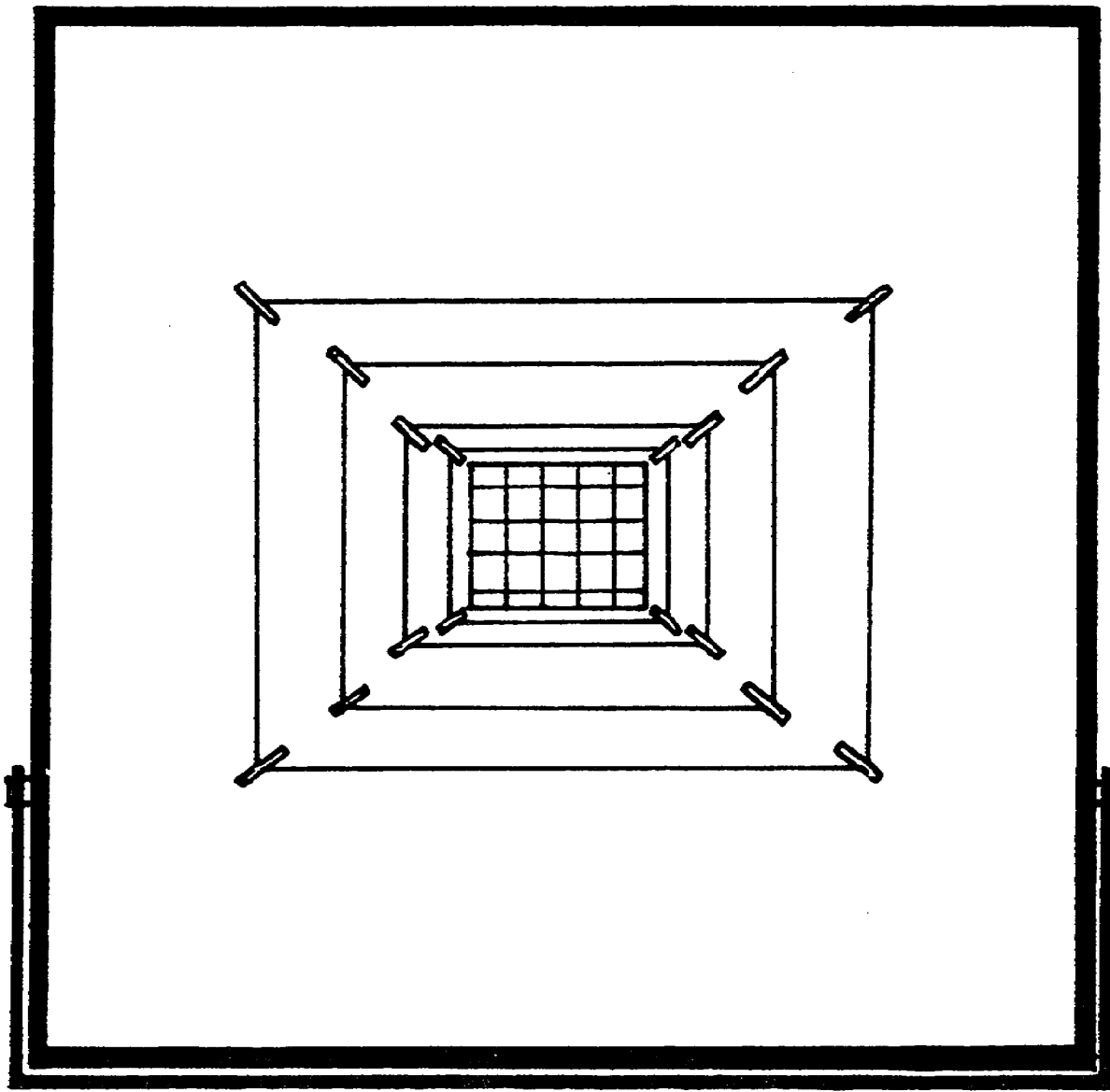


Figure 1-48. Easel with standard masks.

1-15. DESCRIPTION OF CABINET. The cabinet is a completely enclosed unit with an adjustable shelf. The doors of the cabinet can be locked closed by a latch located on the right-hand door.

a. Two rear top bed brackets and two front top bed brackets, mounted on the cabinet, hold the camera during horizontal operation.

b. During vertical operation, the camera is held by two side bed brackets and the two front top bed brackets, and is secured in position by bed latch brackets and latch fasteners.



1-16. DESCRIPTION OF LENS ASSEMBLY. The lens assembly includes a lens, shutter, lens board, and cable release (fig 1-49).

a. Lens. The lens is a four-element anastigmatic-type XII copying unit. It has a focal length of 12 inches and a maximum aperture of  $f/6.3$ . The lens elements are coated to reduce internal reflections.

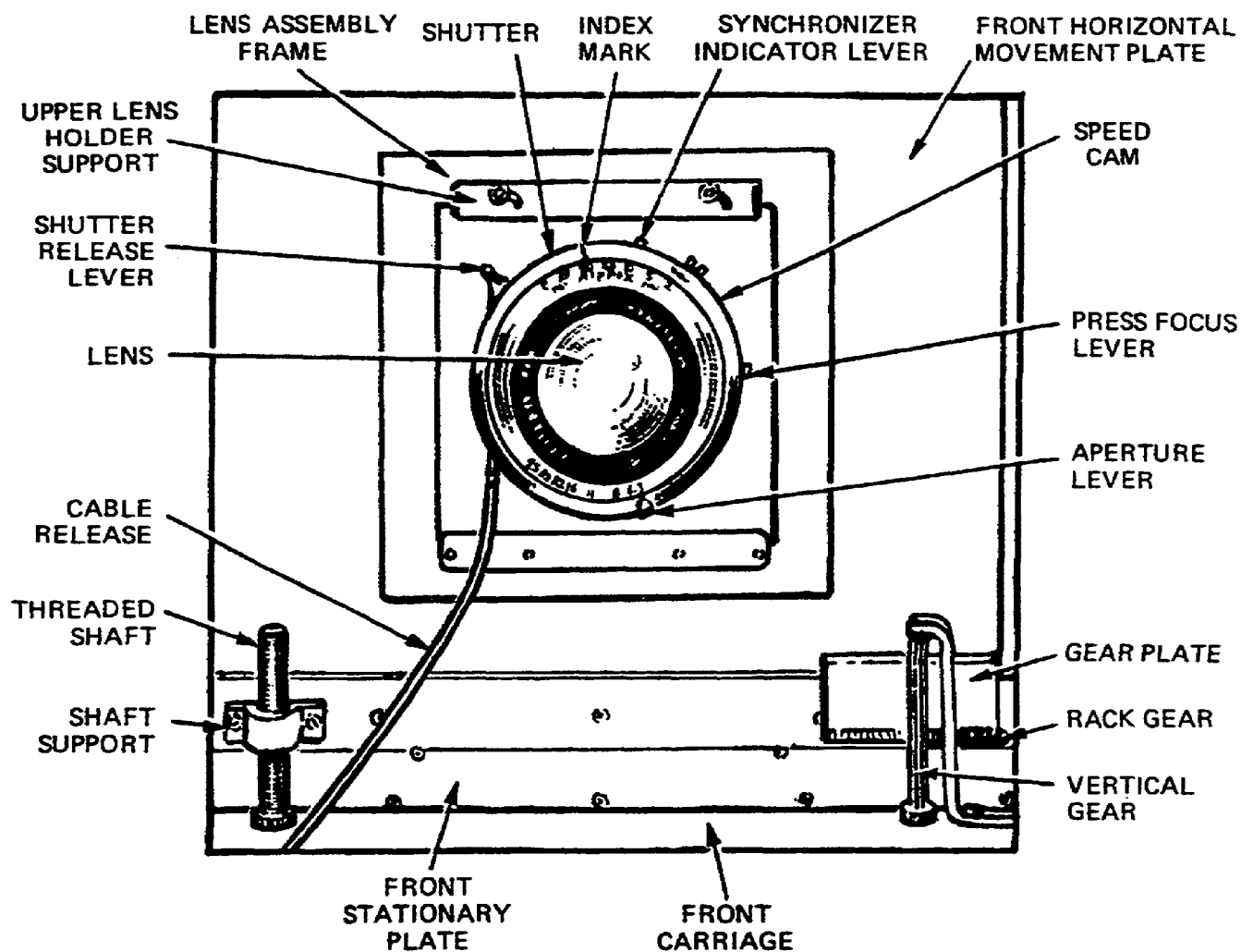


Figure 1-49. Lens Assembly.



b. Shutter. The shutter has five automatically timed speed settings (1/50, 1/25, 1/10, 1/5, 1/2 sec.), plus time (T), bulb (B), and seven aperture settings (f/6.3, 8, 11, 16, 22, 32, 45). The shutter also contains an internal synchronization mechanism and a press focus lever to open and close the shutter to facilitate focusing.

c. Lens board. The lens board is provided to permit mounting the lens assembly in the front frame of the camera. The front vertical movement plate with the threaded shaft and shaft support, and the front horizontal movement plate with the vertical gear and rack gear, shift the lens board and lens to position the image on the ground focusing glass.

d. Cable release. The cable release is provided for remote operation of the shutter, to permit making T, B, or instantaneous (I) exposures without jarring the lens or causing camera movement.

---

## REVIEW EXERCISE

35. What are the two different sizes of focusing backs used with the KS-7A camera?

\_\_\_\_\_ and \_\_\_\_\_.

36. What is mounted on the front frame? \_\_\_\_\_  
\_\_\_\_\_.

37. Where is the focusing back located on the camera body? \_\_\_\_\_  
\_\_\_\_\_.

38. What controls cause horizontal or vertical movement of the lens assembly?  
\_\_\_\_\_  
\_\_\_\_\_.

39. What must you do to increase the distance (focal length) between the front and rear camera carriages? \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_.





40. What size are the interlocking masks of the KS-7A?

\_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_.

41. When using the 5x7-inch mask, what other masks must you use?

\_\_\_\_\_.

42. What are the four main components of the lens assembly?

\_\_\_\_\_.

43. What are the seven speed selections available for use on the KS-7A copy camera? \_\_\_\_\_

\_\_\_\_\_.

44. What f/stops are available with the 12-inch focal length lens used with the KS-7A camera? \_\_\_\_\_

\_\_\_\_\_.

1-17. DESCRIPTION OF LIGHTING SYSTEM. The lighting system consists of a converter and two light assemblies.

a. Converter. The converter is used to manually or automatically operate the light assemblies. The converter permits control of the light assemblies to obtain even illumination and balanced color temperature over the entire surface of the easel. A 20-foot power cord is permanently attached to the converter. When set up for operation, the converter is secured to the rear of the cabinet by means of two converter mounting screws.

b. Light assemblies. The two light assemblies use standard incandescent lamps (four 150-watt incandescent lamps in each assembly). The light assemblies are supported by a carriage assembly (two support arms) that is secured to the front end block. Each light assembly has its own 15-foot interconnection cable (light assembly cable).



## 1-18. DESCRIPTION OF MINOR COMPONENTS.

a. Ground focusing glass. The 4x5-inch focusing back and the 8x10-inch focusing back are provided with a 4x5-inch ground focusing glass and an 8x10-inch ground focusing glass, respectively. When either of the focusing backs is installed on the camera, the ground focusing glass is positioned in the focal plate to permit focusing the image from the lens and to define the picture area.

b. Film holders. Six 4x5-inch film holders and six 8x10-inch film holders are furnished with the camera set. During operation, a loaded film holder is inserted in the focusing back. The film is positioned in the focal plane to record the image after it has been sharply focused on the ground focusing glass (a. above).

c. Filter holder. The filter holder positions standard 4x4-inch photographic filters in front of the camera lens. The filter is used when it is necessary to alter the film spectral response. More on this subject will be explained in greater detail in a later lesson.

d. Opal glass. The opal glass provides even illumination when transparencies, or other materials that are illuminated from the rear, are being copied.

e. Camel's hair brush. The camel's hair brush is used for removing dust from the glass parts of the camera set. The brush is contained within its own metal case.

1-19. CAMERA OPERATION. Before you can confidently operate the 8x10-inch copy camera, you must know something about the various controls and their functions.

a. Camera controls (fig 1-50).

CONTROL	FUNCTION
Front handwheel .....	Image size adjustment. Rotating front handwheel clockwise moves camera toward easel to increase



CONTROL	FUNCTION						
	image size. Rotating front handwheel counterclockwise moves camera away from easel to decrease image size.						
Rear handwheel .....	Coarse focus adjustment Rotating rear handwheel clockwise moves rear carriage toward front frame to decrease bellows extension. Rotating rear handwheel counterclockwise moves rear carriage away from front frame to increase bellows extension.						
Front locking handles ..... <b>NOTE.</b> A locking handle is located at each end of the front carriage.	Two-position levers:  <table> <tr> <th><u>Position</u></th><th><u>Function</u></th></tr> <tr> <td>Forward...</td><td>Lock front carriage to tubular guide rails.</td></tr> <tr> <td>Backward..</td><td>Unlock front carriage from tubular guide rails.</td></tr> </table>	<u>Position</u>	<u>Function</u>	Forward...	Lock front carriage to tubular guide rails.	Backward..	Unlock front carriage from tubular guide rails.
<u>Position</u>	<u>Function</u>						
Forward...	Lock front carriage to tubular guide rails.						
Backward..	Unlock front carriage from tubular guide rails.						
Rear locking handles ..... <b>NOTE:</b> A locking handle is located at each end of the rear carriage.	Two-position levers:  <table> <tr> <th><u>POSITION</u></th><th><u>FUNCTION</u></th></tr> <tr> <td>Forward...</td><td>Lock rear carriage to tubular guide rails.</td></tr> <tr> <td>Backward..</td><td>Unlock rear carriage from tubular guide rails.</td></tr> </table>	<u>POSITION</u>	<u>FUNCTION</u>	Forward...	Lock rear carriage to tubular guide rails.	Backward..	Unlock rear carriage from tubular guide rails.
<u>POSITION</u>	<u>FUNCTION</u>						
Forward...	Lock rear carriage to tubular guide rails.						
Backward..	Unlock rear carriage from tubular guide rails.						



CONTROL	FUNCTION						
Vertical handle grip .....	Controls vertical movement of lens assembly.						
	<table> <tr> <th><u>Direction of Rotation</u></th><th><u>Function</u></th></tr> <tr> <td>Clockwise.....</td><td>Moves lens assembly downward.</td></tr> <tr> <td>Counter-clockwise.....</td><td>Moves lens assembly upward.</td></tr> </table>	<u>Direction of Rotation</u>	<u>Function</u>	Clockwise.....	Moves lens assembly downward.	Counter-clockwise.....	Moves lens assembly upward.
<u>Direction of Rotation</u>	<u>Function</u>						
Clockwise.....	Moves lens assembly downward.						
Counter-clockwise.....	Moves lens assembly upward.						
Horizontal handle grip.....	Controls horizontal movement of lens assembly.						
	<table> <tr> <th><u>Direction of Rotation</u></th><th><u>Function</u></th></tr> <tr> <td>Clockwise.....</td><td>Moves lens assembly to the left.</td></tr> <tr> <td>Counter-clockwise.....</td><td>Moves lens assembly to the right.</td></tr> </table>	<u>Direction of Rotation</u>	<u>Function</u>	Clockwise.....	Moves lens assembly to the left.	Counter-clockwise.....	Moves lens assembly to the right.
<u>Direction of Rotation</u>	<u>Function</u>						
Clockwise.....	Moves lens assembly to the left.						
Counter-clockwise.....	Moves lens assembly to the right.						
Back focusing handle .....	Fine focus adjustment.						
	<table> <tr> <th><u>Directions of Rotation</u></th><th><u>Function</u></th></tr> <tr> <td>Clockwise.....</td><td>Moves camera back away from lens assembly.</td></tr> <tr> <td>Counter-clockwise.....</td><td>Moves camera back toward lens assembly.</td></tr> </table>	<u>Directions of Rotation</u>	<u>Function</u>	Clockwise.....	Moves camera back away from lens assembly.	Counter-clockwise.....	Moves camera back toward lens assembly.
<u>Directions of Rotation</u>	<u>Function</u>						
Clockwise.....	Moves camera back away from lens assembly.						
Counter-clockwise.....	Moves camera back toward lens assembly.						





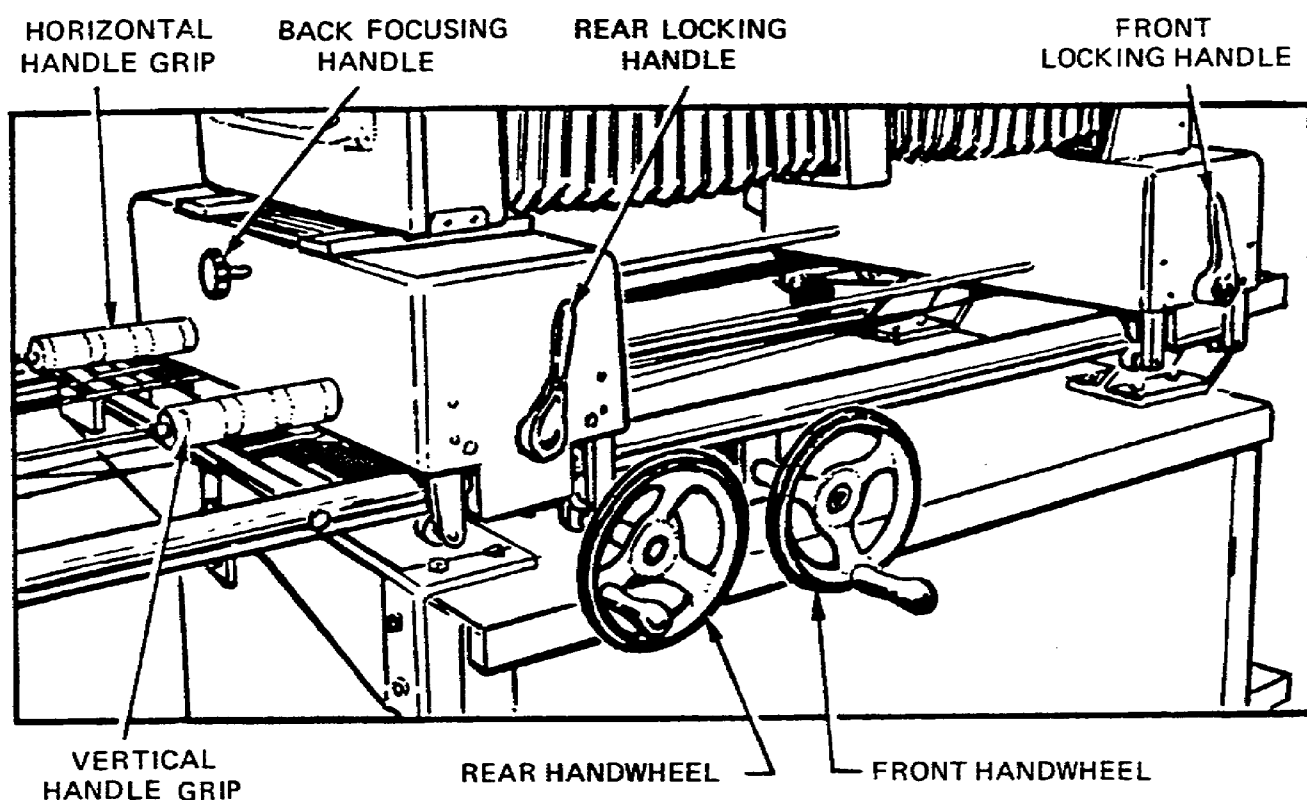


Figure 1-50. Camera Controls.

b. Lens assembly controls (fig 1-51).

CONTROL	FUNCTION
Shutter release lever .....	Operates shutter. Tripping shutter downward opens and closes shutters in speeds from 1/2 through 1/50 of a second, as determined by setting of speed cam. When speed cam is set to T, tripping shutter release lever once opens shutter; tripping shutter release lever a second time closes shutter.



CONTROL	FUNCTION														
	When speed cam is set to B, shutter release lever must be held down (shutter remains open) for desired length of exposure.														
Synchronizer indicator level .....	Flash circuit adjustment control:														
	<table> <tr> <th><u>Position</u></th><th><u>Function</u></th></tr> <tr> <td>X (left).....</td><td>Synchronizes shutter with electronic flash.</td></tr> <tr> <td>M (right).....</td><td>Synchronizes shutter with electronic flash.</td></tr> </table>	<u>Position</u>	<u>Function</u>	X (left).....	Synchronizes shutter with electronic flash.	M (right).....	Synchronizes shutter with electronic flash.								
<u>Position</u>	<u>Function</u>														
X (left).....	Synchronizes shutter with electronic flash.														
M (right).....	Synchronizes shutter with electronic flash.														
Speed cam (circular disk).....	Shutter speed adjustment control:														
	<table> <tr> <th><u>Position</u></th><th><u>Function</u></th></tr> <tr> <td>2.....</td><td>Set shutter speed at 1/2 sec.</td></tr> <tr> <td>5.....</td><td>Set shutter speed at 1/5 sec.</td></tr> <tr> <td>10.....</td><td>Set shutter speed at 1/10 sec.</td></tr> <tr> <td>25.....</td><td>Set shutter speed at 1/25 sec.</td></tr> <tr> <td>50.....</td><td>Set shutter speed at 1/50 sec.</td></tr> <tr> <td>T .....</td><td>Set up shutter for double tripping operation (first for opening and second for closing).</td></tr> </table>	<u>Position</u>	<u>Function</u>	2.....	Set shutter speed at 1/2 sec.	5.....	Set shutter speed at 1/5 sec.	10.....	Set shutter speed at 1/10 sec.	25.....	Set shutter speed at 1/25 sec.	50.....	Set shutter speed at 1/50 sec.	T .....	Set up shutter for double tripping operation (first for opening and second for closing).
<u>Position</u>	<u>Function</u>														
2.....	Set shutter speed at 1/2 sec.														
5.....	Set shutter speed at 1/5 sec.														
10.....	Set shutter speed at 1/10 sec.														
25.....	Set shutter speed at 1/25 sec.														
50.....	Set shutter speed at 1/50 sec.														
T .....	Set up shutter for double tripping operation (first for opening and second for closing).														



CONTROL	FUNCTION						
	B.....Shutter set for exposures longer than 1/2 second.						
Press focus lever .....	Shutter opening (for focusing) control:						
	<table> <tr> <th><u>Position</u></th><th><u>Function</u></th></tr> <tr> <td>Down.....</td><td>Opens shutter for focusing. Latches open until released manually.</td></tr> <tr> <td>Up.....</td><td>Closes shutter.</td></tr> </table>	<u>Position</u>	<u>Function</u>	Down.....	Opens shutter for focusing. Latches open until released manually.	Up.....	Closes shutter.
<u>Position</u>	<u>Function</u>						
Down.....	Opens shutter for focusing. Latches open until released manually.						
Up.....	Closes shutter.						
Aperture lever .....	Aperture size adjustment control. Moving lever to left (toward f/45) decreases aperture size. Moving lever to right (toward f/6.3) increases aperture size.						
Cable release.....	Plunger (not shown) on end of cable release used to operate shutter in same manner as shutter release lever.						



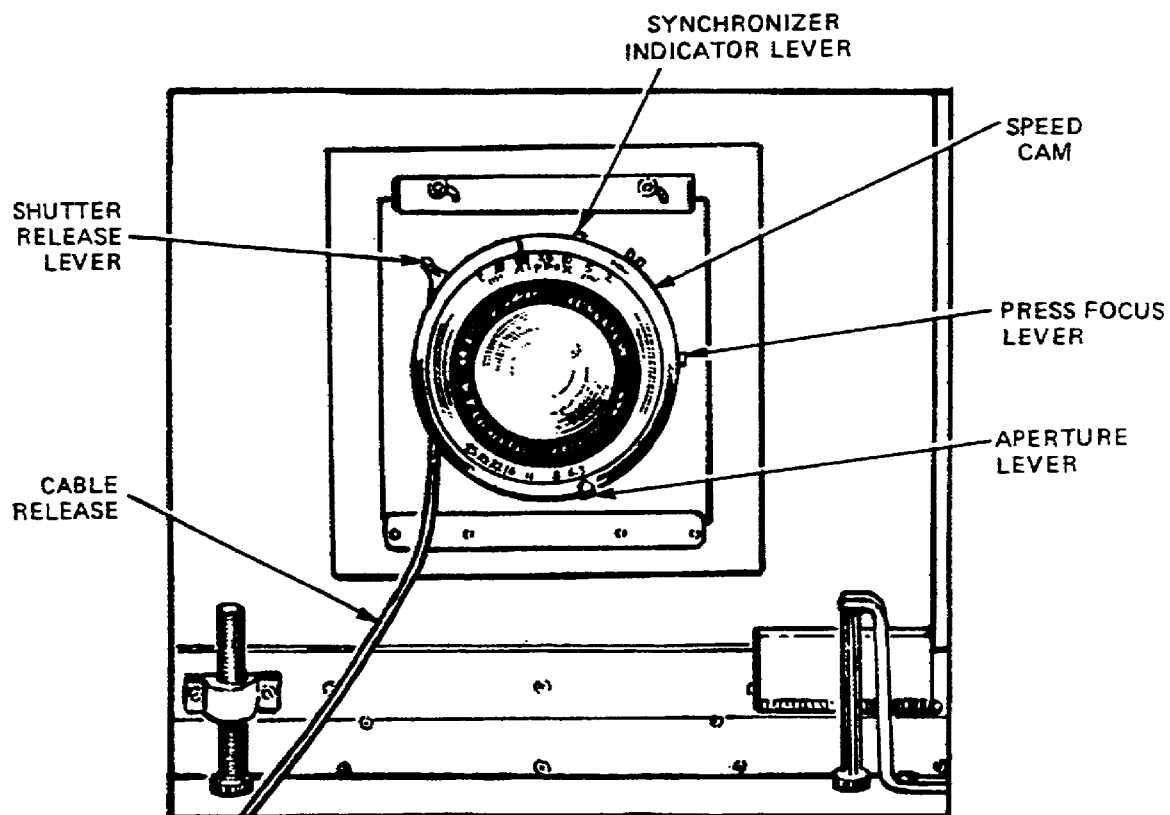


Figure 1-51. Lens Assembly Controls.





c. Converter Controls, Indicators and Connectors (fig 1-52).

CONTROL, INDICATOR, OR CONNECTOR	FUNCTION						
Main power switch .....	ON and OFF switch.						
	<table> <tr> <th><u>Position</u></th><th><u>Function</u></th></tr> <tr> <td>ON.....</td><td>Applies power to converter.</td></tr> <tr> <td>OFF .....</td><td>Disconnects power from converter.</td></tr> </table>	<u>Position</u>	<u>Function</u>	ON.....	Applies power to converter.	OFF .....	Disconnects power from converter.
<u>Position</u>	<u>Function</u>						
ON.....	Applies power to converter.						
OFF .....	Disconnects power from converter.						
Pilot light .....	Neon indicator; lights when <u>main power switch</u> is set to on.						
Ammeter .....	<p>0 to 30 ampere range: indicates amount of current being drawn by converter.</p> <p>NOTE. Indication should not exceed 30 amperes when power source is low voltage (105-125V ac), or 15 amperes when power source is high voltage (210-230V ac).</p>						
Kelvin meter .....	Dual scale ac voltmeter: indicates converter output voltage and related color temperature in degrees Kelvin that light assemblies produce.						
Interval timer receptacle.....	Two-prong female receptacle: permits connection of interval timer.						
Manual-timer switch.....	Operates manual or timer.						
	<table> <tr> <th><u>Position</u></th><th><u>Function</u></th></tr> <tr> <td>Manual operation</td><td>Sets up converter output to be controlled (ON or OFF) by main power switch.</td></tr> </table>	<u>Position</u>	<u>Function</u>	Manual operation	Sets up converter output to be controlled (ON or OFF) by main power switch.		
<u>Position</u>	<u>Function</u>						
Manual operation	Sets up converter output to be controlled (ON or OFF) by main power switch.						



CONTROL, INDICATOR, OR CONNECTOR	FUNCTION																
	<p><b>NOTE.</b> Lamps will operate only at voltage selected by KELVIN TEMPERATURE SELECTOR SWITCH.</p> <p>Remote timer operation.....Sets up converter output to be low or to be controlled by interval timer.</p> <p><b>NOTE.</b> If interval timer is not used, lamps will operate at reduced voltage until switch is set to <u>manual operation</u>. If interval timer is used, lamps will operate at reduced voltage until interval timer operates. Then, lamps will operate at voltage selected by <u>kelvin temperature selector switch</u>. When cycle of interval timer is over, lamps will again operate at reduced voltages.</p>																
Kelvin temperature selector switch .....	Seven-position rotary switch.																
	<table> <tr> <th><u>POSITION</u></th><th><u>FUNCTION</u></th></tr> <tr> <td>1 .....</td><td>Selects output of 120V ac at 2900°K.</td></tr> <tr> <td>2 .....</td><td>Selects output of 131V ac at 2992°K.</td></tr> <tr> <td>3 .....</td><td>Selects output of 142V ac at 3084°K.</td></tr> <tr> <td>4 .....</td><td>Selects output of 153V ac at 3176°K.</td></tr> <tr> <td>5 .....</td><td>Selects output of 164V ac at 3268°K.</td></tr> <tr> <td>6 .....</td><td>Selects output of 175V ac at 3360°K.</td></tr> <tr> <td>7 .....</td><td>Selects output of 186V ac at 3450°K.</td></tr> </table> <p><b>NOTE.</b> The above outputs are based</p>	<u>POSITION</u>	<u>FUNCTION</u>	1 .....	Selects output of 120V ac at 2900°K.	2 .....	Selects output of 131V ac at 2992°K.	3 .....	Selects output of 142V ac at 3084°K.	4 .....	Selects output of 153V ac at 3176°K.	5 .....	Selects output of 164V ac at 3268°K.	6 .....	Selects output of 175V ac at 3360°K.	7 .....	Selects output of 186V ac at 3450°K.
<u>POSITION</u>	<u>FUNCTION</u>																
1 .....	Selects output of 120V ac at 2900°K.																
2 .....	Selects output of 131V ac at 2992°K.																
3 .....	Selects output of 142V ac at 3084°K.																
4 .....	Selects output of 153V ac at 3176°K.																
5 .....	Selects output of 164V ac at 3268°K.																
6 .....	Selects output of 175V ac at 3360°K.																
7 .....	Selects output of 186V ac at 3450°K.																

on an input voltage of 115V ac.  
61

CONTROL, INDICATOR, OR CONNECTOR	FUNCTION						
Output receptacle (2) .....	Permit connection of cables from light assemblies to converter.						
Input voltage selector switch.....	Six-position rotary switch.						
	<table> <tr> <th><u>Position</u></th><th><u>Function</u></th></tr> <tr> <td>105V, 115V, or 125V .....</td><td>Sets up converter to operate off low voltage (105V ac through 125V ac input).</td></tr> <tr> <td>210V, 220V, or 230V .....</td><td>Sets up converter to operate off high voltage (210V ac through 230V ac) input.</td></tr> </table>	<u>Position</u>	<u>Function</u>	105V, 115V, or 125V .....	Sets up converter to operate off low voltage (105V ac through 125V ac input).	210V, 220V, or 230V .....	Sets up converter to operate off high voltage (210V ac through 230V ac) input.
<u>Position</u>	<u>Function</u>						
105V, 115V, or 125V .....	Sets up converter to operate off low voltage (105V ac through 125V ac input).						
210V, 220V, or 230V .....	Sets up converter to operate off high voltage (210V ac through 230V ac) input.						
	<b>NOTE.</b> Switch is set to position which most nearly matches input voltage.						
105/125V ac receptacle .....	When <u>input cord</u> is connected to 105/125V ac receptacle, converter is set up to operate off low voltage input.						
210/230V at receptacle .....	When <u>input cord</u> is connected to 210/230V ac receptacle, converter is set up to operate off high voltage input.						



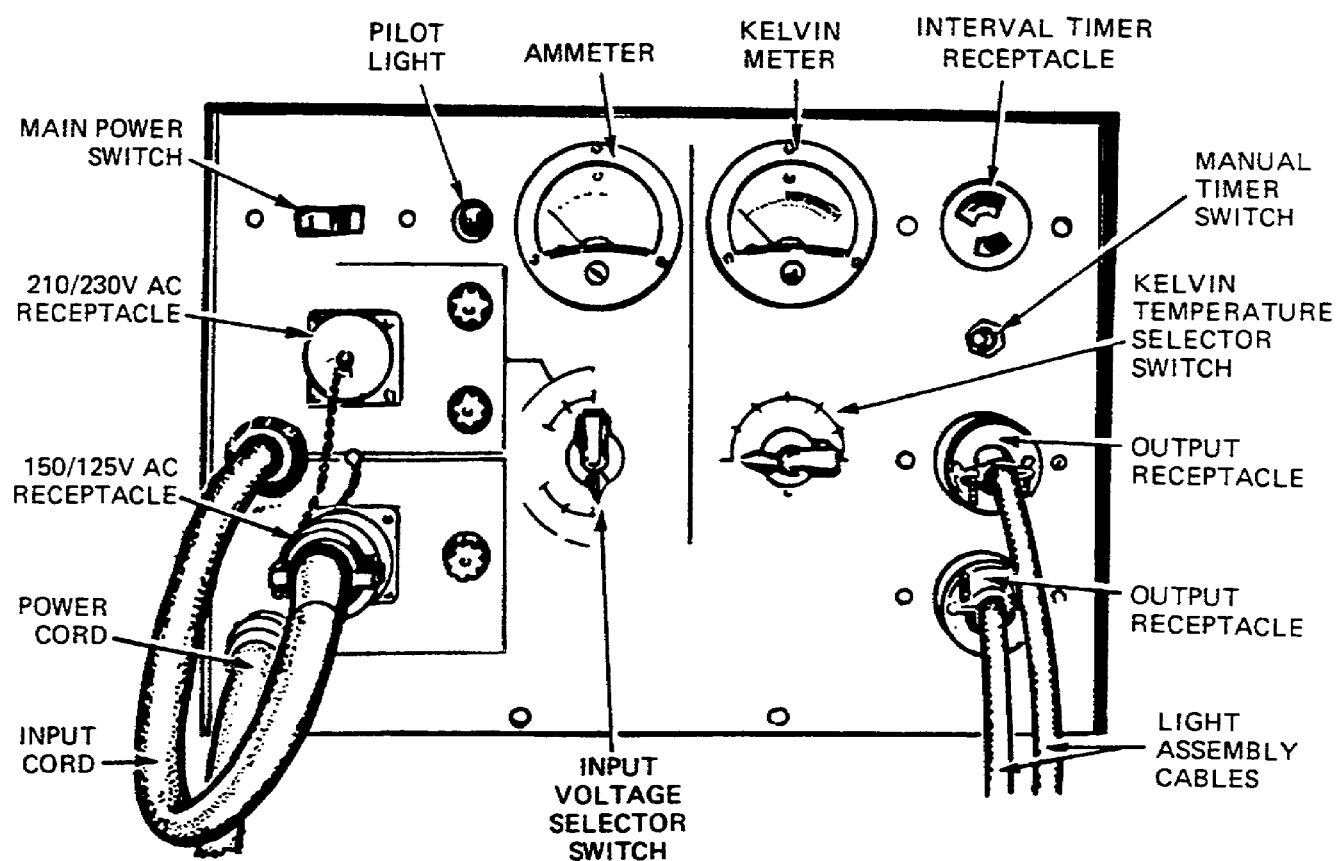


Figure 1-52. Converter Controls.

# REVIEW EXERCISE

45. What is the purpose of the CONVERTER used with the KS-7A copy camera?

---



---



---

46. How many lamps are used in the two light assemblies?

---

47. What are the two types (sizes) of cut-film holders used with the KS-7A copy camera? \_\_\_\_\_

---

48. How many cut-film holders are furnished with the KS-7A copy camera?

---



---

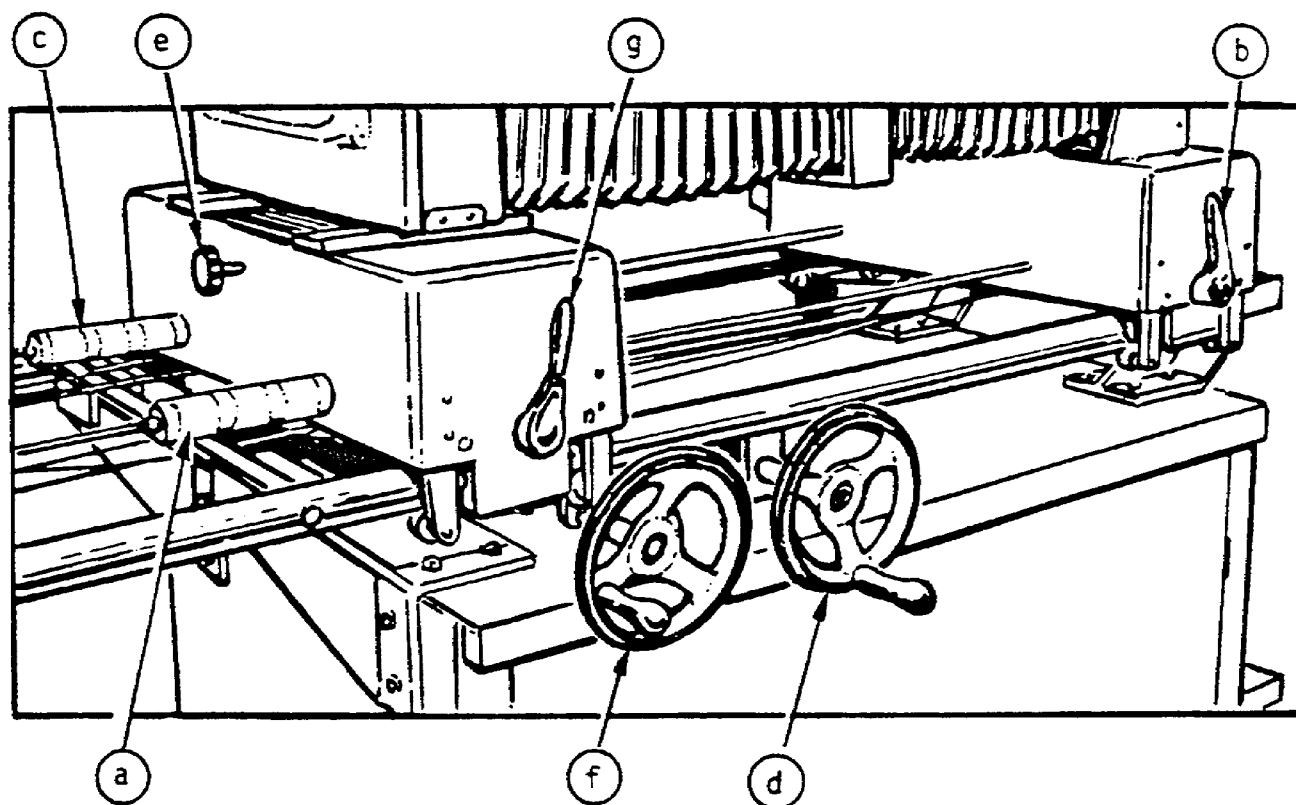




49. Why is a filter used in copy photography? \_\_\_\_\_

50. Fill in the blanks below with the letter that shows the correct location in the illustration.

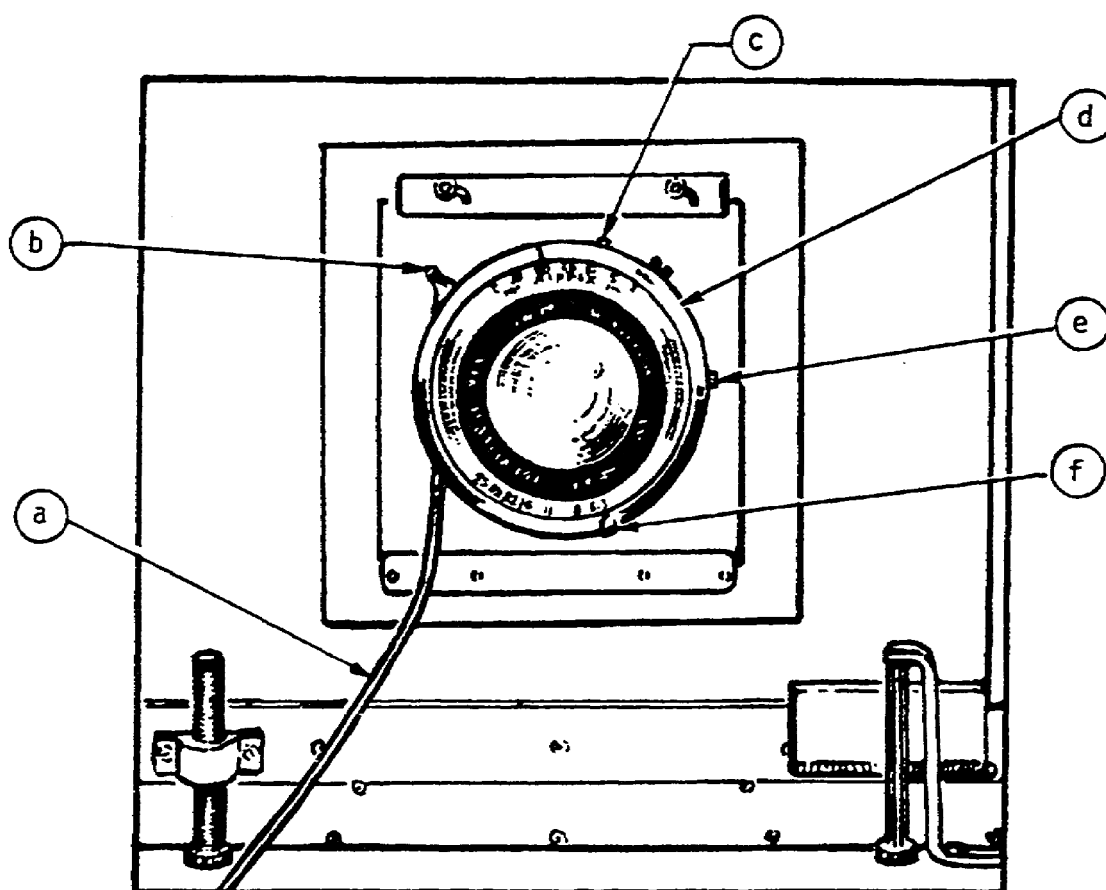
<u>ITEM</u>	<u>LETTER</u>	<u>ITEM</u>	<u>LETTER</u>
Front handwheel	_____	Rear handwheel	_____
Vertical handle grip	_____	Back focusing handle	_____
Front locking handle	_____	Horizontal handle	_____
Rear locking handle	_____	grip	_____





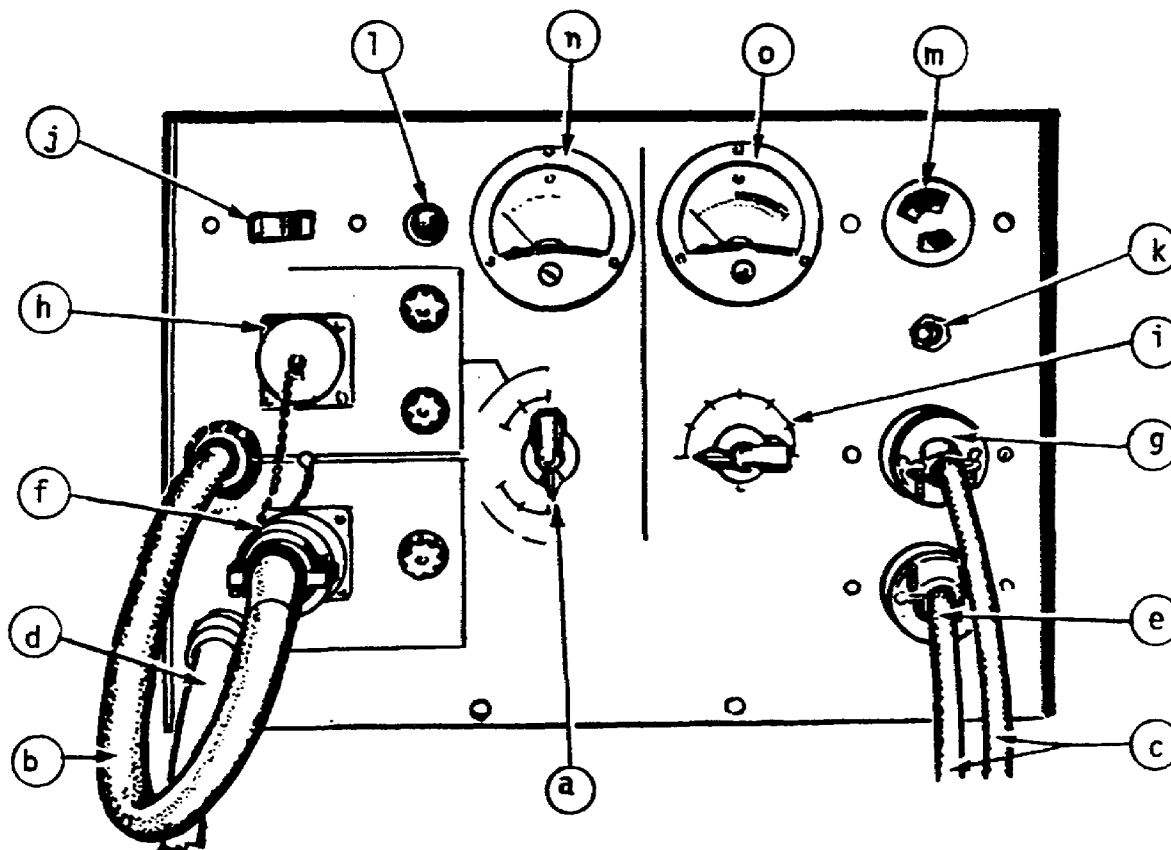
51. Fill in the blanks below with the letter that shows the correct location in the illustration.

<u>ITEM</u>	<u>LETTER</u>	<u>ITEM</u>	<u>LETTER</u>
Aperture lever	_____	Cable release	_____
Lens	_____	Press focus lever	_____
Shutter release lever	_____	Synchronizer indicator lever	_____
Index mark	_____	Shutter	_____





52. Fill in the blanks below with the letter that shows the correct location in the illustration.



LETTER      ITEM

\_\_\_\_\_ Ammeter  
 \_\_\_\_\_ Interval timer receptacle  
 \_\_\_\_\_ Input voltage selector switch  
 \_\_\_\_\_ Input cord  
 \_\_\_\_\_ 210/230V ac receptacle  
 \_\_\_\_\_ Main power switch  
 \_\_\_\_\_ Output receptacle(2)

LETTER      ITEM

\_\_\_\_\_ Pilot light  
 \_\_\_\_\_ Kelvin temperature selector switch  
 \_\_\_\_\_ Power cord  
 \_\_\_\_\_ 150/125V ac receptacle  
 \_\_\_\_\_ Manual timer switch  
 \_\_\_\_\_ Kelvin meter  
 \_\_\_\_\_ Light assembly cables

.....



1-20. LOADING FILM HOLDERS. To load the 4x5-inch film holders, follow the procedures in para 1-10 a, b.

a. Film loading procedures should be performed in a photographic darkroom. However, any room or space which is clean, dust free, and completely blocks out all light may be used. Loading the film holders in other than total darkness may ruin the film. Be sure to read and understand the loading procedures before attempting to load any holder.

b. Loading 8x10-inch film holders. The following procedures apply to each of the 8x10-inch film holders, (fig 1-53).

(1) Place the film holder on a clean work surface. Make sure the holders are clean and free of dust.

(2) Pull out the slide and partially reinsert it in the film holder. Make sure that the bright side of the slide (notches) faces out.

(3) Open the hinged bottom of the film holder. Hold the hinged bottom open with the left hand and the film in the right hand, with the forefinger on the notches. Make sure that the notches are in the position as shown, so that the emulsion (dull) side will face up.

(4) Slide the film into the grooves along the sides of the film holder, until it is fully inserted. Close the hinged bottom.

(5) Insert the slide completely into the film holder and into the hinged bottom.

(6) Set the locking screw (not shown) to hold the slide in position.

(7) Turn the film holder over and load the opposite side by repeating the procedures in (1) through (6) above.





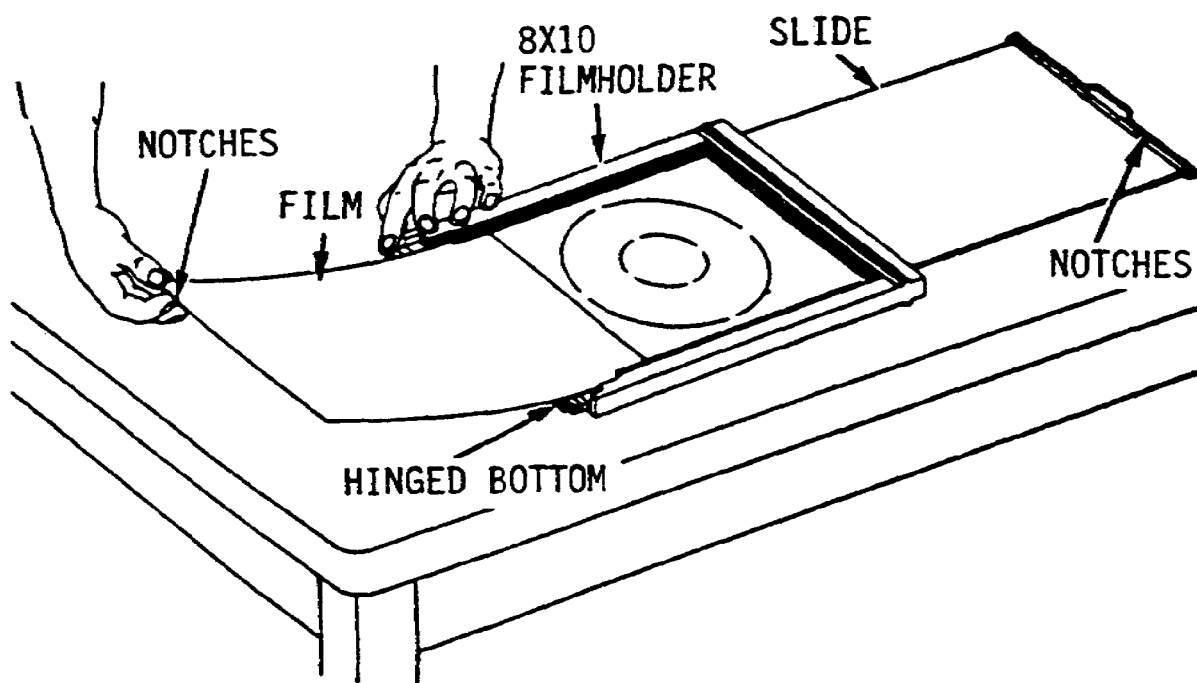


Figure 1-53. Loading 8x10-inch film holder.

1-21. PREPARING LIGHTING SYSTEM. To prepare the lighting system of the KS-7A for operation, first adjust the output converter and then adjust the position of the light assembly.

a. Converter. Prepare the converter for operation as follows (fig 1-52):

- (1) Check to be sure that the main power switch is set to OFF.
- (2) Check to be sure that the power cord is connected to the power source and that input voltage-selector switch is set to the position that most likely matches the voltage of the power source.

**NOTE.** The value of the voltage at the power source will have been marked on the output receptacle at the time the camera set was installed by maintenance personnel.

- (3) Set the manual-timer switch to remote time operation.
- (4) Set the main power switch to ON; the pilot light will glow and the lamps in the light assemblies will glow dimly.
- (5) Set the kelvin temperature selector switch to 1.
- (6) Set the manual-timer switch to manual operation.



(7) Adjust the kelvin temperature selector switch to the position at which the Kelvin meter indicates the desired color temperature.

b. Light assemblies. The light assemblies can be positioned either in front of the easel or in back of the easel. Adjust the position of the light assemblies as follows:

- (1) Loosen the knob located on the outside of the top of each light assembly.
- (2) Remove the stabilizing bar from the stabilizing bar brackets.
- (3) Swing the light assemblies (mounted on the support arms) to the front of the easel for copying opaque material, or to the back of the easel for copying transparent material.
- (4) Align the light assemblies so that even illumination is obtained on the easel.
- (5) Loosen the knobs located inside the top of each light assembly and align the stabilizing bar brackets.
- (6) Install the stabilizing bar in the stabilizing bar brackets and tighten the knobs (both inside and outside the light assemblies).

1-22. LOADING EASEL. The easel can be loaded with standard size rigid copy, with nonstandard size or nonrigid copy, or with a negative or a color transparency.

a. Standard size rigid copy. To load the easel with a standard size rigid copy, proceed as follows:

- (1) Select the mask that matches the size of the copy.
- (2) Secure the mask (or masks) to the front of the easel.
- (3) Secure the copy within the mask with the clips provided at the corners.

b. Nonstandard size or nonrigid copy. To load the easel with nonstandard size or nonrigid copy, proceed as follows:

- (1) Tip the easel to the right (horizontal) position.
- (2) Release the latch fasteners and open the easel.



(3) Place the copy over the scale on the mounting plate, or within the border lines as necessary.

(4) Close the easel and secure the latch fasteners.

(5) Raise the easel to the vertical position.

c. Negative or color transparency. To load the easel with a negative or color transparency of a standard size, follow the procedures in (1) below. To load the easel with a negative or color transparency that is not of a standard size, follow the procedures in (2) below.

(1) Standard size.

(a) Release the latch fasteners, open the easel, and remove the plate and the sponge rubber padded mounting board.

(b) Close the easel and secure the latch fasteners.

(c) Install the opal glass in the rear of the easel; use the easel corner clips.

(d) Secure the negative or color transparency to the front of the easel with the photographic mask or masks (a. above).

(2) Nonstandard size.

(a) Follow the procedures in (1)(a) and (1)(b) above.

(b) Install the opal glass in the front of the easel; use the easel corner clips.

(c) Tape the negative or color transparency directly to the opal glass.

## 1-23. OPERATING PROCEDURES. Setting up the camera.

Set up the camera for operation as follows:

a. Load the film holder (4x5-inch or 8x10-inch) that will be required, (para 1-10 or 1-20).



- b. Load the easel with the object to be copied, (para 1-22).
- c. Install the 4x5-inch or the 8x10-inch focusing back to accommodate the required film holders (4x5-inch or 8x10-inch).
- d. Prepare the converter and light assemblies for operation, (para 1-21).

1-24. ADJUSTING SIZE AND FOCUSING. The camera set will produce copies the same size as the original, enlargements of the original, or reductions of the original.

The following procedure may be used to obtain the required size:

- a. Remove the lens cap from the front of the lens.
- b. Set the aperture lever to f/6.3. This setting will admit the maximum amount of light and produce the minimum depth of field for sharp focusing.
- c. Press down on the press focus lever. The shutter will open, and remain open, to permit focusing.
- d. Move all four locking handles on the carriages backward to release the carriages.
- e. Rotate the front handwheel (clockwise or counter-clockwise, as required) until the image on the ground focusing glass is approximately the size desired.

**NOTE:** The size of the image can be estimated by using the lines on the ground focusing glass as a guide. The distance between the lines on the 8x10-inch focusing back is  $\frac{1}{2}$  inch. The distance between the lines on the 4x5-inch focusing back is X inch. The image dimensions can range from one-quarter to four times the dimensions of the object being copied. Moving the lens toward the object increases image size, while moving the lens away from the object decreases image size. Maximum reduction is obtained with an object-to-lens distance of approximately 60 inches.

- f. Rotate the rear handwheel on the camera (clockwise or counterclockwise, as required) until the image on the ground focusing glass is coarse focused. Rotate the back focusing handle until the image is sharply focused.





g. If the image is not of the proper size after focusing, repeat the procedures in e. and f. above until a sharp image of the desired size is obtained.

h. Move all four locking handles forward to secure the carriages.

i. Gently lift the press focus lever. The shutter will close.

1-25. ADJUSTING LIGHT ASSEMBLIES AND DETERMINING EXPOSURE. To adjust the light assemblies, follow the-procedures in a. below. To determine the exposure required for the type of copy and image size used, follow the procedures in b. below.

a. Adjusting light assemblies. Adjust the light assemblies as follows:

(1) Position your head in front of the lens assembly and study the illumination of the material to be copied.

(2) Readjust the light assemblies to produce an even illumination with no glare

b. Determining exposure. The exposure required for the type of copy and the image size used may be estimated by the operator, based upon experience. Normally, however, an exposure meter must be used. When an exposure meter is used, proceed as follows:

(1) Operate the exposure meter to measure the light from the material to be copied, and to determine the exposure setting (f/stop and time) for the light measured and for the film used.

(2) The exposure setting obtained (b (1) above) is correct for objects at infinity (a lens operating at a distance from the film equal to the lens focal length). However, the lens used with the camera set operates at a distance from the film much greater (due to the bellows extension) than its 12-inch focal length. As a result, a corrected exposure setting (CES) must be determined (calculated).

(3) Calculate the corrected exposure setting (CES) as follows:

(a) Measure the bellows extension (distance from the center of the lens to the film plane).



(b) Use the following formula to calculate the corrected exposure setting (CES):

$$CES = \left( \frac{BE}{FL} \right)^2 \times EM$$

Where: CES is the corrected exposure setting in seconds.

BE is the bellows extension distance in inches.

FL is the focal length of the lens in inches.

EM is the exposure meter setting in seconds.

EXAMPLE: The camera lens has a 12-inch focal length which is operating with a bellows extension of 27 inches. The exposure meter indicated that an exposure of 7 seconds at f/22 would be correct for the illumination and the film used. Using the formula, find the corrected exposure setting (CES).

$$CES = \left( \frac{BE}{FL} \right)^2 \times EM$$

$$CES = \left( \frac{27}{12} \right)^2 \times 7$$

$$CES = \frac{729}{144} \times 7$$

$$CES = 5.06 \times 7$$

$$CES = 35.4 \text{ seconds}$$

(Therefore, the corrected exposure setting is 35 seconds at f/22).

(4) Upon completion of the corrected exposure setting calculation, set the aperture lever at the required f/stop (b(1) above), set the speed cam at T, and make the copy.



1-26. MAKING COPY. To make a copy negative, proceed as follows:

- a. Insert a loaded film holder into the focusing back.

**NOTE:** The slide of the film holder that faces the lens must have the bright side out, indicating unexposed film.

- b. Release the locking screw on the film holder and remove the slide from the film holder.

- c. The cable release should be used for all exposures to reduce camera movement.

- (1) For exposures of 1 second to 3 seconds, proceed as follows:

- (a) Set the shutter index mark to B (Bulb).
- (b) Press the cable release plunger to open the shutter. Do not release.
- (c) Allow the calculated time to pass.
- (d) Release the plunger.

- (2) For exposures of 4 or more seconds, proceed as follows:

- (a) Set the shutter index to T (Time).
- (b) Press the cable release plunger to open the shutter.
- (c) Release the plunger.
- (d) Allow the calculated time to pass.
- (e) Press the cable release plunger a second time to close the shutter.

- d. Replace the slide in the film holder with the black (dull) side of the slide out, to indicate the film has been exposed.

- e. Set the locking screw on the film holder to hold the slide in position; remove the film holder from the focusing back.



- f. Shut down the camera set.
- g. Process the exposed film.

---

## REVIEW EXERCISES

53. You are given two 8x10-inch transparencies to be copied. To insure proper lighting of the transparency, how should you place the camera lights?

\_\_\_\_\_

\_\_\_\_\_.

54. What controls color temperature of the lights on the KS-7A camera?

\_\_\_\_\_

\_\_\_\_\_.

55. What must you do to obtain sharp focus on the ground glass after the initial coarse focus? \_\_\_\_\_

\_\_\_\_\_.

56. What is the next thing you do, after the camera is fine focused and secured on the carriage? \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_.

57. You are getting ready to copy an object. The camera is fine focused and you measure a bellows extension distance of 35 inches. Your exposure meter gave you a reading of f/32 at 8 seconds. Calculate the corrected exposure setting (CES) using the formula below. Camera focal length is 23 inches.

$$\text{CES} = \left( \frac{\text{BE}}{\text{FL}} \right)^2 \times \text{EM}$$

CES = \_\_\_\_\_

58. You have to copy a chart using the KS-7A camera. Focal length is 12 inches, bellows extension in 22 inches, exposure meter shows 2 seconds at f/16. What is your CES?

\_\_\_\_\_.





59. You must make an exposure at 18 seconds at f/16 on the KS-7A camera. Using the cable release, which type of exposure setting should you use?

---

---

60. You should always use the cable release when using the KS-7A camera. Circle the correct answer.

TRUE

FALSE

---

## 1-27. SUMMARY.

This first lesson has provided you with a general knowledge of the three basic cameras used in copy photography. You have also studied the operating procedures for each.

You will use this lesson as a guide when you have the equipment available and begin practicing for the SOJT portion of the training. Good luck as you progress through the course.



## LESSON I

### EXERCISE SOLUTIONS

1. REPRONAR. (para 1-2a).
2. KS-7A, (para 1-3).
3. 4x5-inch View Camera, (para 1-2d).
4. Shutter release button,(para 1-4a).
5. Read exposure counter number (para 1-4a).
6. Use the magnifier, (para 1-4b)
7. On the Film Reminder Dial, (para 1-4c)
8. Controls the action of the lens diaphragm, (para 1-4d)
9. Turn the Diaphragm Ring to the selected f/stop, (para 1-4f)
10.
  - a. Index 18
  - b. Camera Exposure f/8
  - c. Upper Scale 4
  - d. Lower Scale 4. (para 1-4g).
11. f/11-16, (para 1-4g(1)).
12. The REPRONAR flash is ready to be fired, (para 1-4i)
13. 1.5 amp fuse, (para 1-4j)
14. Four times (two f/stops), (para 1-4i)
15. Pull the rewind crank handle out, (para 1-5c).
16. True, (para 1-5g).
17. Press the rewind button extension shaft and hold it down, unfold the rewind crank handle, and crank film back into the cassette, open camera back and remove film cassette, (para 1-5i).
18. Align the slots with the tabs, place cord connection on camera receptacle, push lightly toward the rear on the cord and turn cable connector clockwise to insure cord locks into place, (para 1-6 a, b, c).



19.
  - a. Exposure calculator selector wheel, (para 1-4g)
  - b. Film index window, (para 1-4g)
  - c. Magnification scale-upper, (para 1-4g)
  - d. Camera carriage pointer, (para 1-4g)
  - e. Aperture window, (para 1-4g)
  - f. Camera aperture bar, (para 1-4g)
  - g. Magnification scale-Lower, (para 1-4g)
  - h. Opal view glass, (para 1-4h)
  - i. Control panel, (para 1-4i)
  - j. Film advance lever, (para 1-4a)
  - k. Shutter knob, (para 1-4a)
  - l. Shutter release button, (para 1-4a)
  - m. Magnifier, (para 1-4b)
  - n. Crank for rewind, (para 1-4c)
  - o. Camera case catch, (para 1-4c)
  - p. Film reminder dial, (para 1-4c)
  - q. Synch cord, (para 1-6a)
  - r. Aperture selector pointer, (para 1-4e)
  - s. Diaphragm ring, (para 1-4f)
  - t. Lens carriage pointer, (para 1-4g)
  - u. Filter compartment & holder, (para 1-4h)
  
20.
 

<ol style="list-style-type: none"> <li>a. Lens board retainer</li> <li>b. Pinion knob</li> <li>c. Cocking lever</li> <li>d. Focus button</li> <li>e. Flash unit terminals</li> <li>f. Synchronism adjustment</li> </ol>	<ol style="list-style-type: none"> <li>g. Synchronization Selector lever</li> <li>h. Front slide and swing lock knob</li> <li>i. Lens aperture selector</li> <li>j. f/stop scale</li> <li>k. Shutter release lever</li> <li>l. Speed selector ring (fig 1-29)</li> </ol>
---	--
  
21.
  - a. Camera level vial
  - b. Rear frame
  - c. Ground glass
  - d. Pressure back
  - e. Rear carriage
  - f. End stop
  - g. Rear carriage release lever
  - h. Rear carriage lock knob
  - i. Camera mount adjust knob
  - j. Monorail bed
  - k. Front carriage lock knob
  - l. Front carriage
  - m. Bellows
  - n. Front frame
  - o. Carrying handle (fig 1-27 and 1-28)



22. Up and away from the cut-film holder, (para 1-10b(6)).
23. By locating the identification code notches on the film sheet, and making sure that it is located in the upper right hand corner, prior to loading the film into the holder, (para 1-10b(3)).
24. The dark slide is inserted into the film pack adapter, (para 1-10c(1)).
25. Set lens f/stop to widest opening, depress cocking lever, depress focus button, (para 1-11a(1)(a)(b)(c)).
26. Increase or decrease the distance between the front and rear carriage (sec 1-11a(2),(3)).
27. Loosen the center lock post knob and slide the center post up to the desired height, (para 1-11a(4)(b)).
28. Loosen the tilt lock knob and, with the tripod control handle, tilt the camera to the desired angle, (para 1-11a(4)(c)).
29. Rotate the spring-loaded pinion knob until the desired degree of correction is achieved, (para 1-11b(1)).
30. Move the monorail bed with respect to the panhead, (1-11b(2)).
31. Slide the front or rear frame or both with respect to its carriage, (1-11b(3)).
32. Front pivot lock knob, (para 1-11b(4)(a))
33. Rotate the camera back (para 1-11b(6)).
34. Remove the dark slide from the film holder, (para 1-11b(8)(e)).
35. 4x5-inch and 8x10-inch, (para 1-14).
36. Lens assembly, (para 1-14a(1)).
37. Rear frame, (para 1-14a(4)).
38. Front movement mechanisms, (para 1-14d).
39. Turn the two handwheels, (para 1-14e).
40. 3¼x4-inch, 4x5-inch, 5x7-inch, 8x10-inch, 11x14-inch, (para 1-14h).





41. 8x10-inch and 11x14-inch. (para 1-14h).
42. A lens, shutter, lens board, and a cable release, (para 1-16).
43. T, B, 1/50, 1/25, 1/10, 1/5, 1/2 sec, (para 1-16b).
44. f/6.3, 8, 11, 16, 22, 32, 45, (para 1-16b).
45. Permits control of the light, for even illumination and balance color temperature, (para 1-17a).
46. Eight, (para 1-17b).
47. 4x5-inch and 8x10-inch, (para 1-18b).
48. Six 4x5-inch and six 8x10-inch, (para 1-18b).
49. To alter the film spectral response, (para 1-18c).
50. 

a. Vertical handle grip	e. Back focusing handle
b. Front locking handle	f. Rear handwheel
c. Horizontal handle grip	g. Rear locking handle
d. Front handwheel	(para 1-19a).
51. 

a. Cable release	d. Speed cam
b. Shutter release lever	e. Press focus lever
c. Synchronizer indicator lever	f. Aperture lever
	(para 1-19b, fig 1-51)
52. 

a - Input voltage selector switch
b - Input cord
c - Light assembly cables
d - Power cord
e - Output receptacle
f - 150/125V ac receptacle
g - Output receptacle
h - 210/230V ac receptacle
i - Kelvin temperature selector switch
j - Main power switch
k - Manual-timer switch
l - Pilot light
m - Interval timer receptacle
n - Ammeter
o - Kelvin meter
(para 1-19c, fig 1-52)
53. In back of the easel, (para 1-21b(3)).



54. Kelvin temperature selector switch, (para 1-21a(7))

55. Operate the back focusing handle, (para 1-24f)

56. Close the lens, (para 1-24i)

$$57. \quad \text{CES} = \left( \frac{\text{BE}}{\text{FL}} \right)^2 \times \text{EM} \quad \text{or} \quad \frac{35^2}{(23)^2} \times 8 =$$

$$\frac{1225}{529} \times 8 = 2.3 \times 8 = 18.5 \text{ seconds}$$

CES = 18.5 seconds @ f/32, (para 1-25b(3)(a)(b)).

58. 6.7 seconds @ f/16, (para 1-25b(3)(a)(b)).

59. Time (T), (para 1-26c(2)(a)).

60. True, (para 1-26c).



## LESSON 2

### OPTICS

#### Lesson Objective:

When you have completed this lesson you will be able to:

1. Identify basic characteristic of lenses.
2. Describe focal plane and focal length.
3. Identify performance features of lenses.
4. Describe ratio and scale.

These objectives support the following tasks:

113-578-1006	Compute Electronic Flash Exposure and Ratio
113-578-1013	Photograph Subjects Using Various Focal Length Lenses
113-578-1015	Employ Photographic Composition

2-1. INTRODUCTION: In order to produce clear usable images, you must have a special flat field lens. In this lesson you will be taught basic optics and how the different lenses work.

2-2. The purpose of a camera lens is to refract light rays in such a manner that a sharp, clear image is formed. Camera lenses are designed to function with the least amount of error and to reproduce objects in a practical object-image size relationship.

2-3. THE PINHOLE LENS. The simplest type of lens is a pinhole in a piece of thin metal or black paper, (fig 2-1). Only an extremely small part of the light reflected by a subject passes through the pinhole to form an image in the camera.

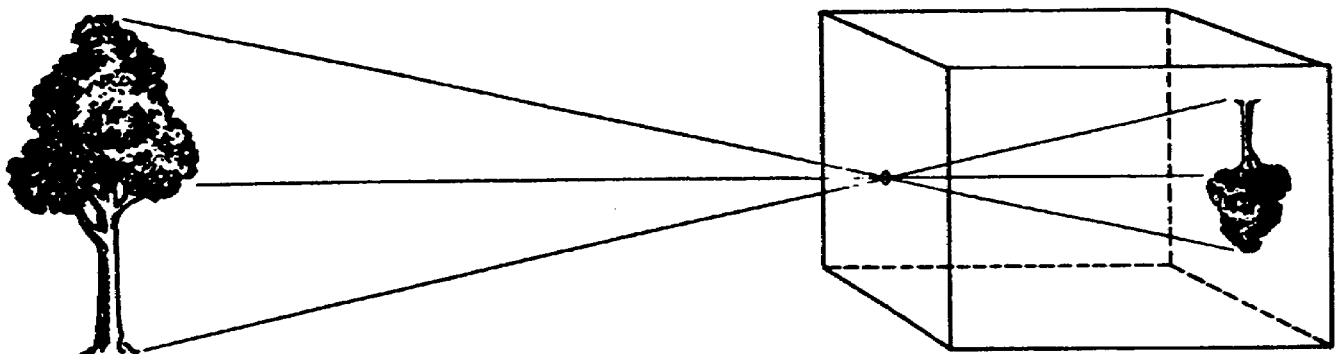


Figure 2-1. Image produced by small pinhole.



If the pinhole is made larger, (fig 2-2), more light passes through the opening and the image becomes blurred because of the overlapping of several images.

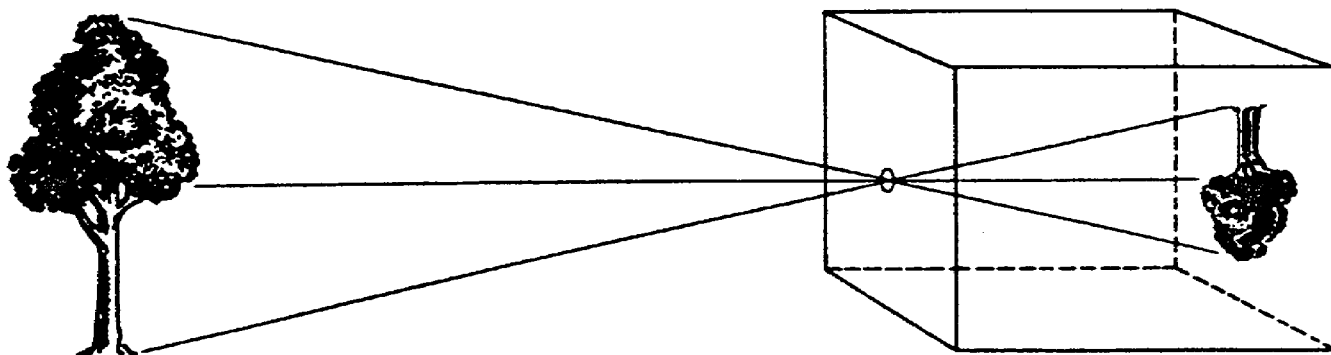


Figure 2-2. Image produced by large pinhole.

The images produced by light passing through a small pinhole are sharper than those passing through a large pinhole. No pinhole, however, is capable of producing a critically sharp image. Because of this, and other limiting factors, pinhole lenses are not practical for general photography.

2-4. CAMERA LENSES. A camera lens is a piece of polished spherical and symmetrical glass that refracts light rays so that an image of a desired scene is projected on the rear wall of a camera. A lens transmits more light than a pinhole, and it increases the brightness and improves the sharpness of the image. The basic principle of a lens – any lens - is relatively simple.

a. First, consider an image formed with a single pinhole. Next, consider another pinhole above the first. This pinhole forms a second image. If these two images could be made to coincide, the result would be an image twice as bright as the original.

b. Now, consider a third pinhole on the side of the first, a fourth on the other side, and a fifth below the first. All four pinholes project separate images, slightly removed from the first or center one (fig 2-3).

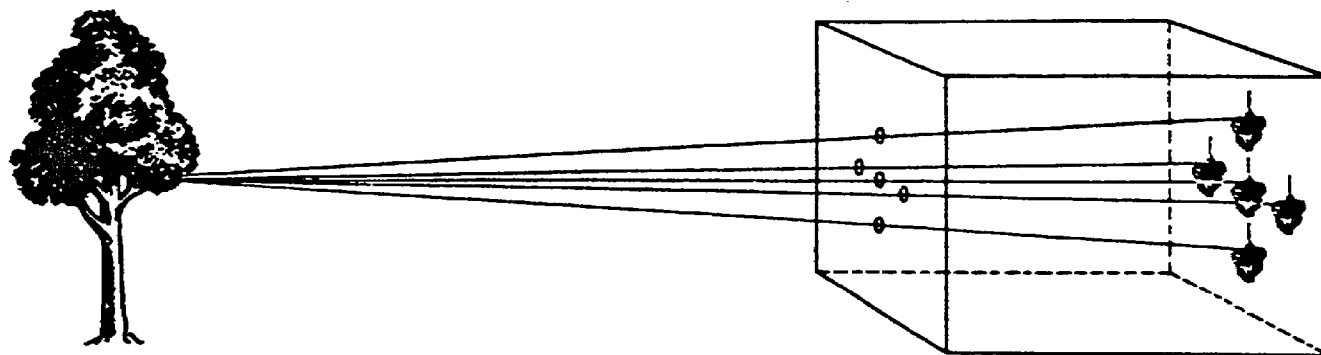


Figure 2-3. Separate images of the same object.





If these four images could be made to coincide with the center one, the result would be an image five times as bright as the image made by the one center pinhole.

c. Next, use the principle of refraction to make these four images coincide with the center one. In other words, place a prism behind each pinhole so that the light forming each of the four images is refracted to form a single image. This image is about five times as bright as the original image, (fig 2-4).

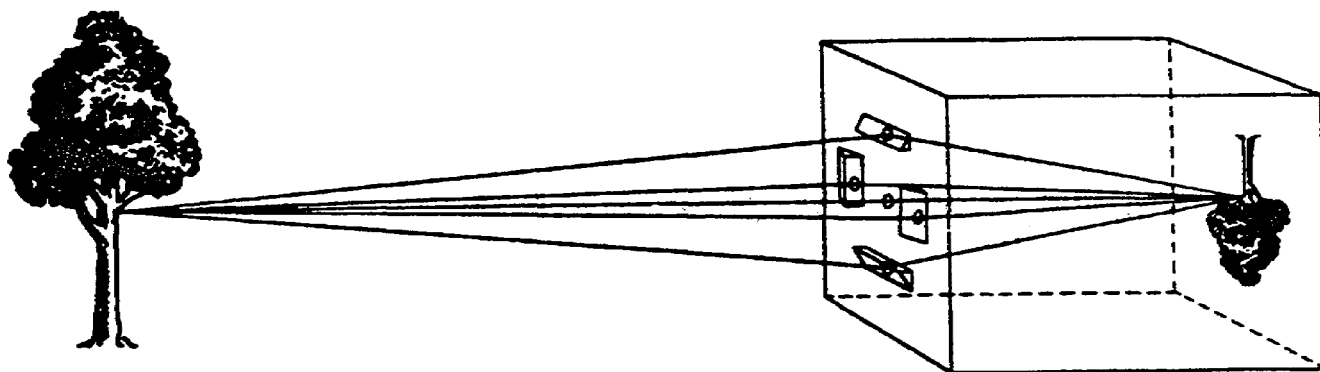


Figure 2-4. Separate images made to coincide.

d. The theory discussed above indicates that the brightness and sharpness of the image depends upon the number of pinholes and prisms used. However, a lens consisting of numerous pinholes and prisms would be too cumbersome for practical use.

e. The camera lens, therefore, consists of a series of prisms incorporated in a single circular piece of glass, and the image is formed in the same manner as if two prisms were placed base to base. This eliminates the need for individual pinholes and prisms, (fig 2-5).

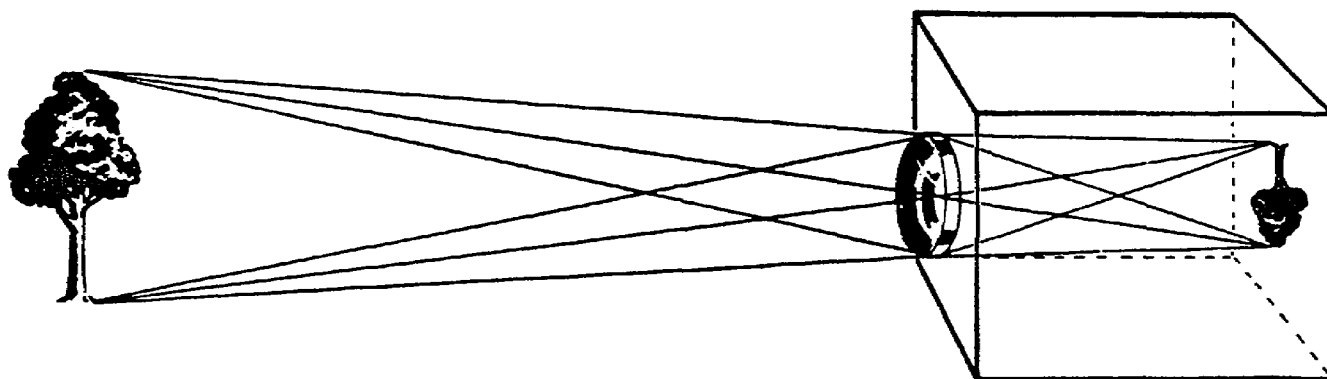


Figure 2-5. Formation of an image by a lens.

2-5. TYPES OF SINGLE LENSES. Single lenses are divided into two general classes; positive lenses and negative lenses.

a. Positive lenses, (fig 2-6).

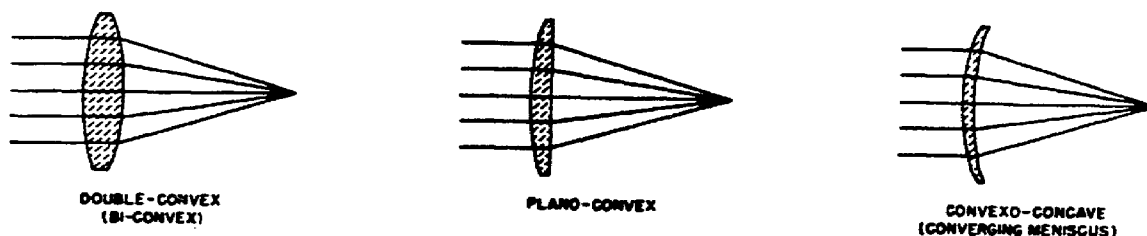


Figure 2-6. Positive Lenses.

Positive lenses form real images because light rays passing through such lenses cross. Lenses in this class are also termed convex, convergent, or collective. Positive lenses, which are convex lenses, are thicker in the center than at the edges and converge light rays. However, one surface may be convex while the other is flat, or one surface may be convex while the other is concave.

(1) Double-convex lenses (bi-convex) have two convex surfaces. Both surfaces contribute to the converging characteristics of the lens.

(2) Plano-convex lenses have a plane surface and convex surface. The plane surface does not contribute to the converging characteristics of the lens.

(3) Convexo-concave lenses (converging meniscus) have both a convex and a concave surface. The more pronounced convex curve makes this a positive lens despite the fact that the concave surface spreads light and subtracts from the converging characteristics of the lens.

b. Negative lenses, (fig 2-7).

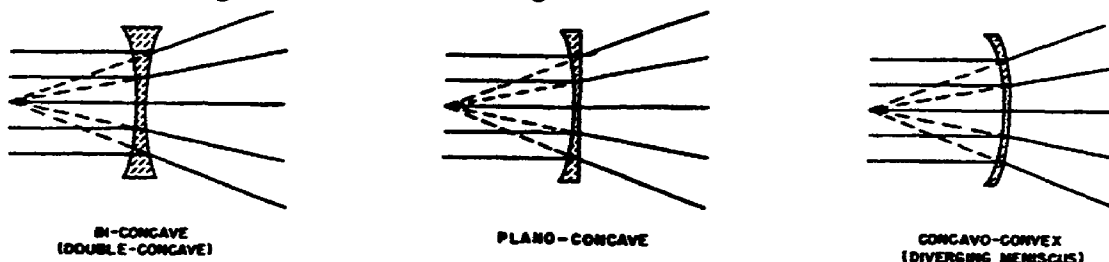


Figure 2-7. Negative Lenses.



Negative lenses form only vertical images because light rays passing through them spread. These lenses are also called concave, divergent, or dispersive. Negative lenses may be used as part of a compound lens to correct aberrations, but cannot be used individually as photographic lenses. Negative lenses, which are concave lenses, spread light rays. These lenses are thinner in the center than at the edge.

(1) Double-concave lenses (bi-concave) have two concave curvatures.

(2) Plano-concave lenses have one concave surface and one piano surface.

(3) Concavo-convex lenses (diverging meniscus) have one face with a concave surface and one face with a convex surface. The concave surface is more strongly curved. The convex surface of either converging or diverging lenses of this type is often toward the light. The location of the more pronounced curve determines whether a lens is convergent or divergent.

**NOTE:** All light is shown entering lenses from left to right.

---

## REVIEW EXERCISES

1. What is a pinhole lens? \_\_\_\_\_  
\_\_\_\_\_.

2. A small pinhole will produce a blurred image and a large pinhole will produce a sharp image.  
(Circle one.)

TRUE

FALSE

3. If you use the principle of refraction in a multiple pinhole camera, the image will be brighter.  
(Circle one.)

TRUE

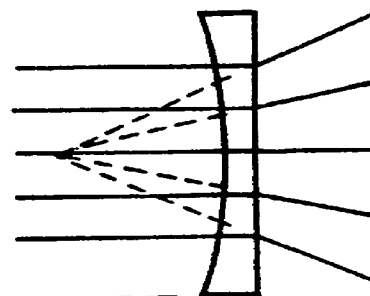
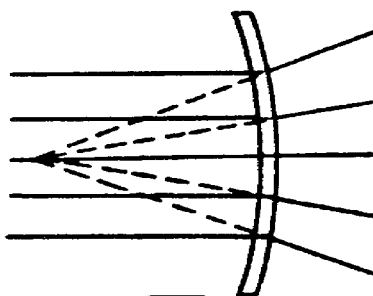
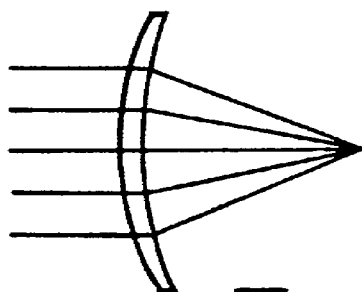
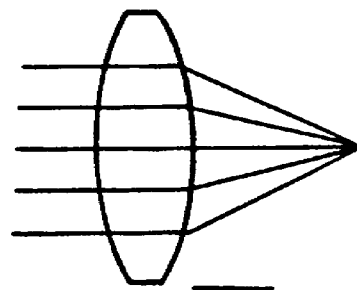
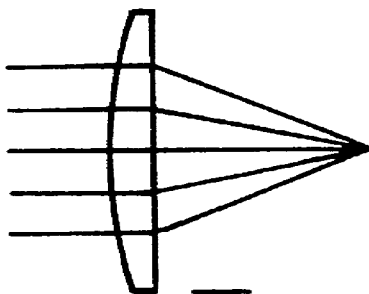
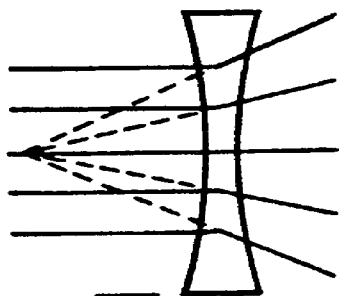
FALSE



4. From the list, identify each type of lens by writing the letter next to the lens in the illustration below.

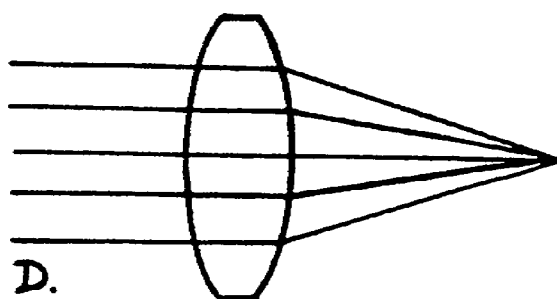
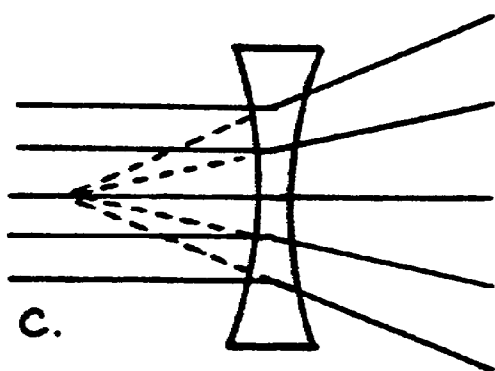
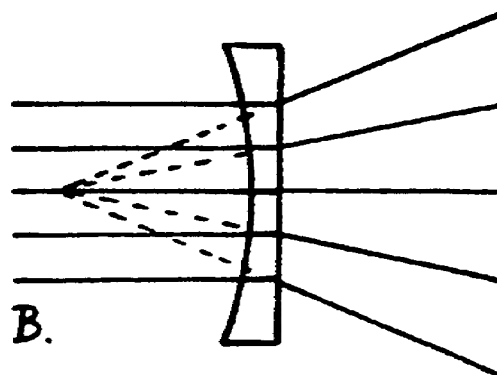
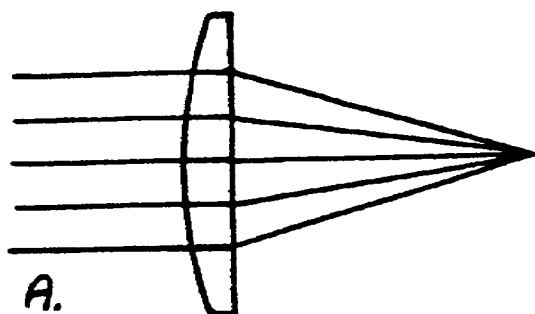
- a. plano-convex
- b. convexo-concave
- c. bi-concave

- d. double-convex
- e. concavo-convex
- f. plano-concave





5. Identify the positive and negative lenses from the illustration below:



Positive lenses \_\_\_\_\_, \_\_\_\_\_. Negative Lenses \_\_\_\_\_, \_\_\_\_\_.

---

## SECTION II

### FOCAL PLANE AND FOCAL LENGTH

#### 2-6. GENERAL.

a. When a lens projects an image, the plane in which the image is sharply formed is called the focal plane.

b. The distance from the optical center of a lens to its focal plane, when the lens is focused at infinity, is called focal length. This distance can be changed in some modern lenses by increasing or decreasing the distance between the front and rear lens elements.





- c. Focal length controls image brightness, lens speed, and image size, (fig 2-8).

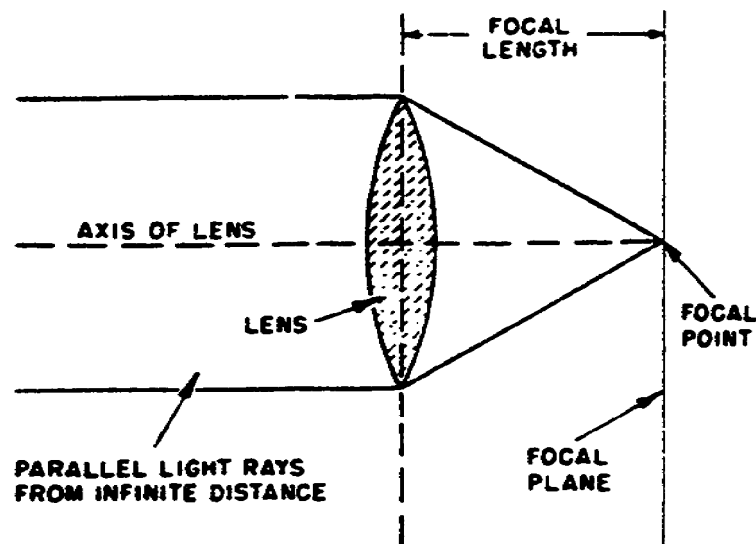


Figure 2-8. Focal Length.

2-7. SPEED OF LENS. The speed of a lens refers to the intensity of the light that forms the image on the film plane.

a. Light intensity. The intensity of the light transmitted by a lens depends upon the diameter of the aperture (diaphragm opening), the number of lens elements, the number of reflecting surfaces, and the focal length of the lens, (fig 2-9). With other factors remaining constant, a large aperture admits more light, or is faster, and a longer focal length decreases the light intensity, or is slower, (fig 2-10). In the same way that a card gets dimmer as a flashlight is moved further away from it, a photographic image becomes dimmer as the focal length is increased, (fig 2-11). This is because light must travel a longer distance to reach the focal plane.



b. Lens aperture. The aperture of a lens, expressed as an f/number, represents the ratio of the focal length to the diameter of the lens opening, as follows:

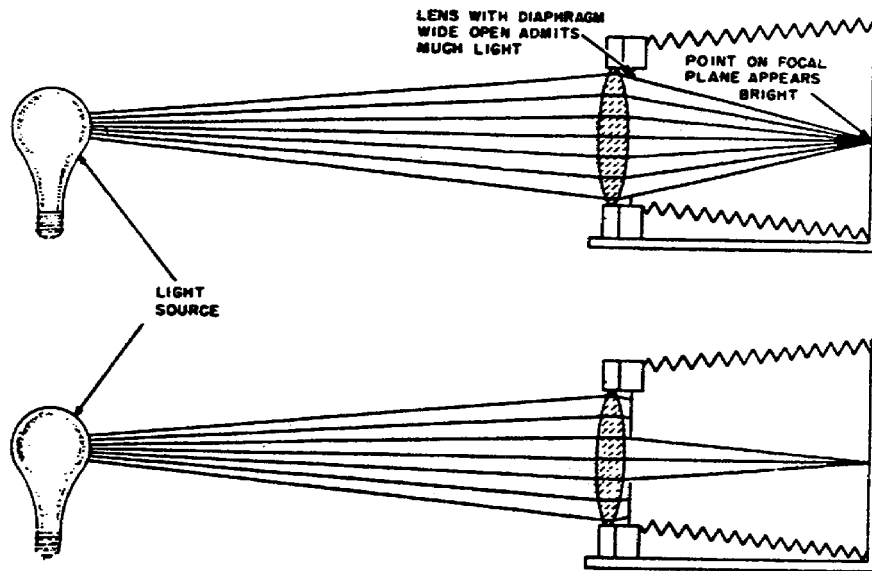


Figure 2-9. Effect of diaphragm opening.

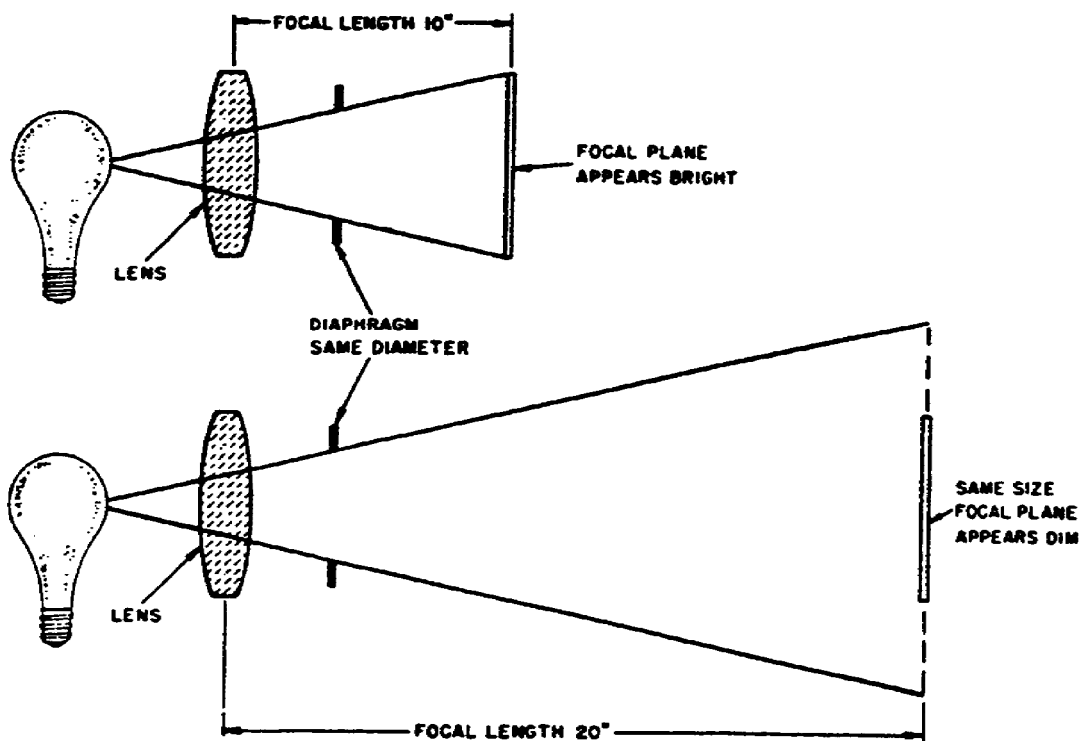


Figure 2-10. Relationship of focal length and light source.



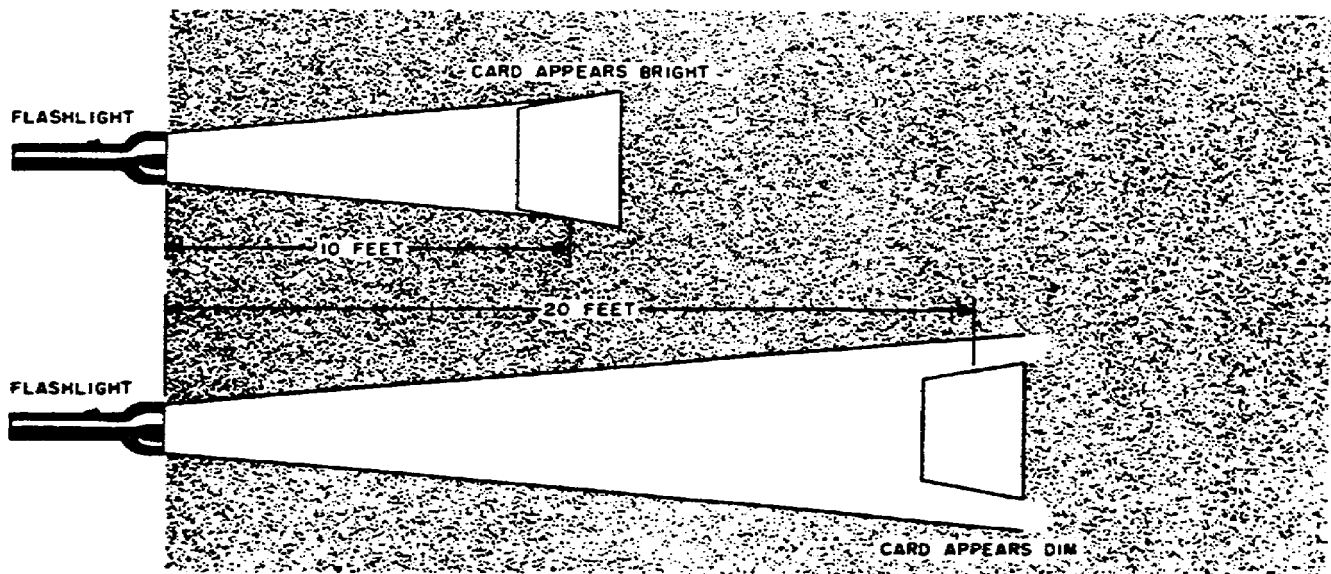


Figure 2-11. Effect of distance on brightness.

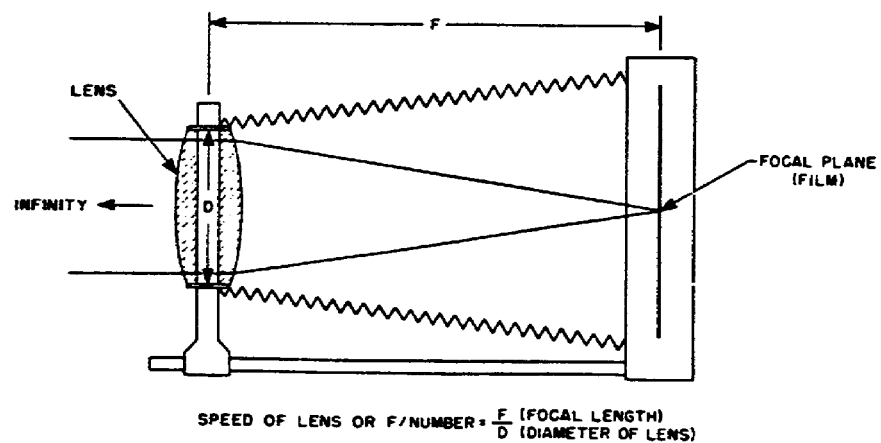


Figure 2-12. Speed (aperture) of a lens.



$$\frac{\text{Focal length}}{\text{Diameter of a lens opening}} = f/\text{number}$$

For example, if a lens has an 8-inch focal length and the diameter of the lens opening is 2 inches, the aperture is f/4, (fig 2-12).

c. Relationship of apertures. The maximum opening of a lens can be reduced by adjusting the camera diaphragm. This will change the size of the aperture and, consequently, its light transmitting ability. If the diaphragm of the f/4 lens, discussed above, is closed down to 1 inch, the effective lens aperture is 8 (8 ' 1 = 8). This is expressed as f/8.

d. Full stops. Full stops are a series of f/numbers, each of which admits either one-half or twice as much light as the preceding f/number. Table 2-1 indicates the amount of light passed by a lens when set at various stops.

f/number, or diaphragm scale sequence.	Units of light passed by the lens in a given time (as the lens is closed down).	Units of light passed by the lens in a given time (as the lens is opened wider).
1.4	1	2048
2	1/2	1024
2.8	1/4	512
4	1/8	256
5.6	1/16	128
8	1/32	64
11	1/64	32
16	1/128	16
22	1/256	8
32	1/512	4
45	1/1024	2
64	1/2048	1

Table 2-1. Full stops.

For example: A lens set at f/5.6 passes one-sixteenth as much light as a lens with an aperture of f/1.4. Consequently, a lens at f/1.4 passes sixteen times more light as a lens with an aperture of f/5.6.





e. Intermediate stops. A continuously variable diaphragm makes possible settings between full stops.

---

## EXERCISE

6. Define "focal plane."

---

---

7. What is the distance between the focal plane and optical center of a lens when focused at infinity called?

---

8. What controls image brightness, lens speed, and image size?

---

(fill-in)

9. What does the term " $f/16$ " identify? \_\_\_\_\_

---

## SECTION III

### LENS PERFORMANCE

2-8. FOCAL LENGTHS OF DIVERGENT LENS. The focal length of a divergent lens, when focused at infinity, is the distance from the node of emergence of the lens to the focal plane. The point of principal focus and other focal points are located where the emergent rays intersect the axis between the object and the lens, (fig 2-13).

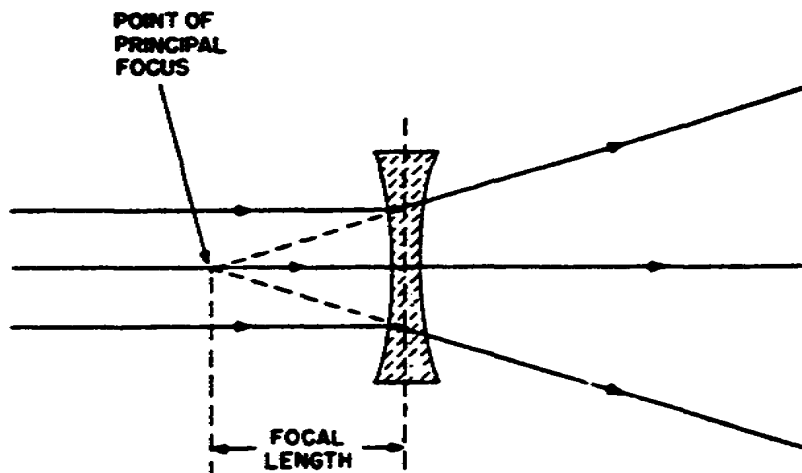


Figure 2-13. Focal length of a divergent lens.

When an object is near a divergent lens, the point of principal focus, the frontal plane, and other focal points are located in front of the lens.

2-9. ANGLE OF FIELD. The angle of field is the widest angle at which light entering a lens will produce, at its focal plane, a circle of good definition. This is the usable portion of the circle of illumination, (fig 2-14).

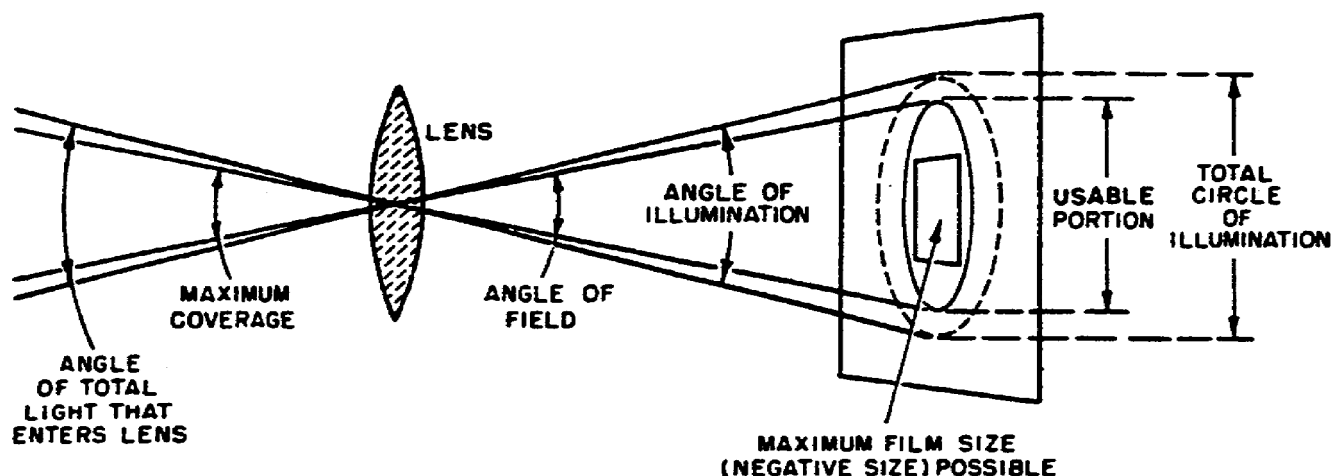


Figure 2-14. Angle of field.

a. A normal (standard) lens has, approximately, the same angle of field as the human eye (about 45° to 55°); a wide-angle lens has a wider angle of field; and long focal length and telephoto lenses have a narrower angle of field.

b. The angle of field has a definite affect on the size of the negative that can be used with a given lens, since any part of the film extending beyond the circle of good definition will yield an indistinct image.

2-10. ANGLE OF VIEW. The angle of view of a photographic lens determines actual coverage when used with a camera of a particular film (negative) size, (fig 2-15). The angle of view of a lens is determined at the time of manufacture.



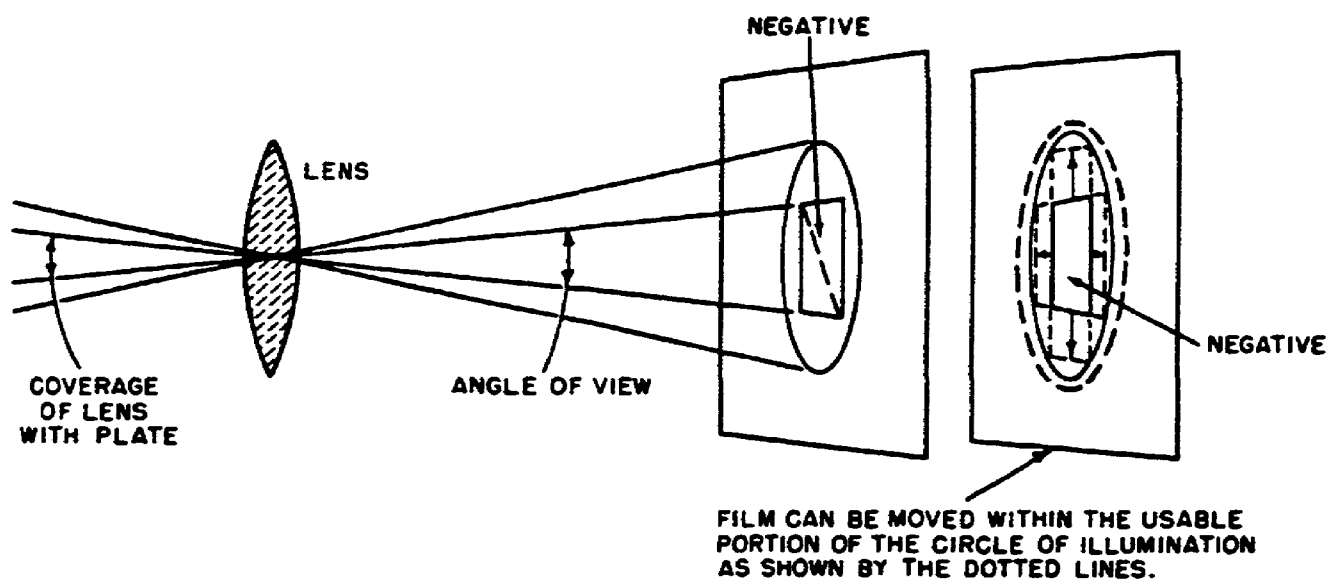


Figure 2-15. Angle of view.

- a. To determine the angle of view, draw a line AB equal to the focal length of the lens. Construct BC perpendicular to AB and locate point C so that BC is equal to one-half of the diagonal of the negative, (fig 2-16). Multiply the size of the angle by two to determine the angle of view.

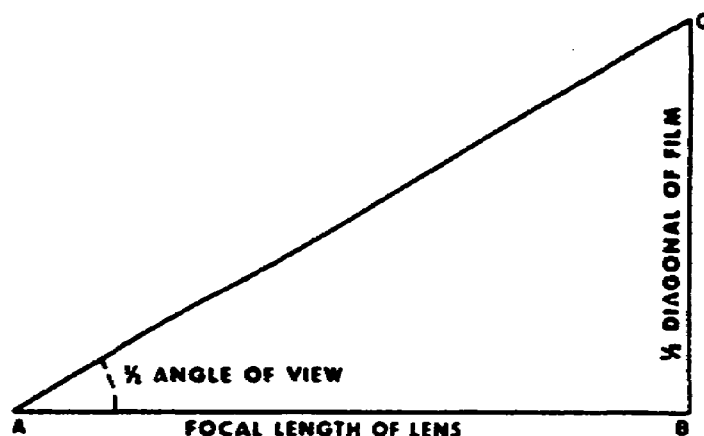


Figure 2-16. Determining angle of view.

- b. While angle of field is an unalterable optical characteristic of a lens, angle of view is a variable depending on focal length of the lens, film size of the camera with which the lens is used, and subject distance.

(1) With a normal lens, the focal length is equal to the diagonal of the negative size used. When a normal focal length is used with a negative having a shorter



diagonal than the focal length of the lens, the result is a narrow angle of view. if the same lens is used with a larger negative, the angle of view is greater. The larger the negative to be covered by a lens of a given focal length, the greater the angle of view.

(2) If the focal length is equal to the diagonal of the negative, the angle of view decreases as the subject distance is shortened.

(3) Since manufacturers usually produce lenses for specific negative sizes, they also prepare tables giving angles of view of commonly used lenses. Some manufacturers also list angle of view for vertical and horizontal measurements of film. For example, the readings for a 5-inch focal length lens are diagonal  $65^\circ$ , horizontal  $53^\circ$ , and vertical  $44^\circ$ .

(4) Figure 2-17 illustrates the angle of view for wide-angle, normal, and long focal length lenses.

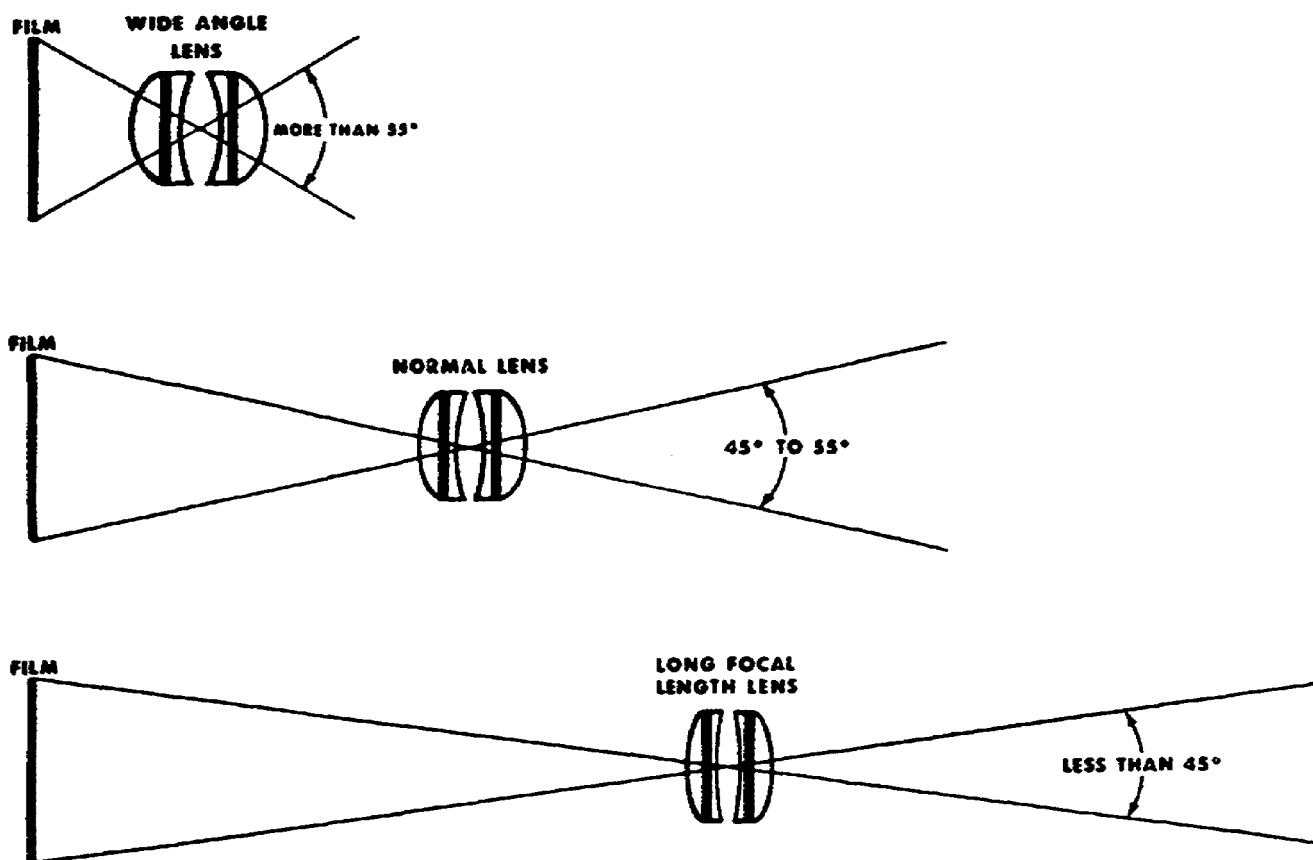


Figure 2-17. Angle of view for various focal length lenses.





c. Angles of view for still camera lenses are shown in table 2-2 and apply to lenses focused at infinity.

Negative size	Focal length of lens	Angle of view
Inches	Inches	Degrees
1 x 1.5	1 2/5	63
1 x 1.5	2	46
1 x 1.5	3 3/5	27
2 1/4 x 2 3/4	2 4/5	64
2 1/4 x 2 3/4	4	46
2 1/4 x 2 3/4	9	22
4 x 5	5	65
4 x 5	6	56
4 x 5	7	49
4 x 5	10	35

Table 2-2. Angles of view of still camera lenses.

2-11. ILLUMINATION OF NEGATIVE. To be uniform, a negative must receive even illumination from a lens. If the margins receive less light than the center, a vignetting effect results. Actually, this effect is so insignificant that it is not obvious at ordinary angles of view. Nevertheless, the vignetting effect is produced by all lenses. When a lens with an angle of view of 90° or more is used, the vignetting effect becomes noticeable.

## 2-12. IMAGE SIZE.

a. If the subject distance remains constant, the focal length of a lens controls the size of an image on the film. A short focal length lens has a wide angle of view and produces, without changing the negative size, a smaller image than a long focal length lens. When two lenses of different focal lengths are used with the same film size, the lens with the longer focal length includes less of the subject area. However, any subject detail in that area appears larger than it would if photographed with a shorter focal length lens, (fig 2-18).



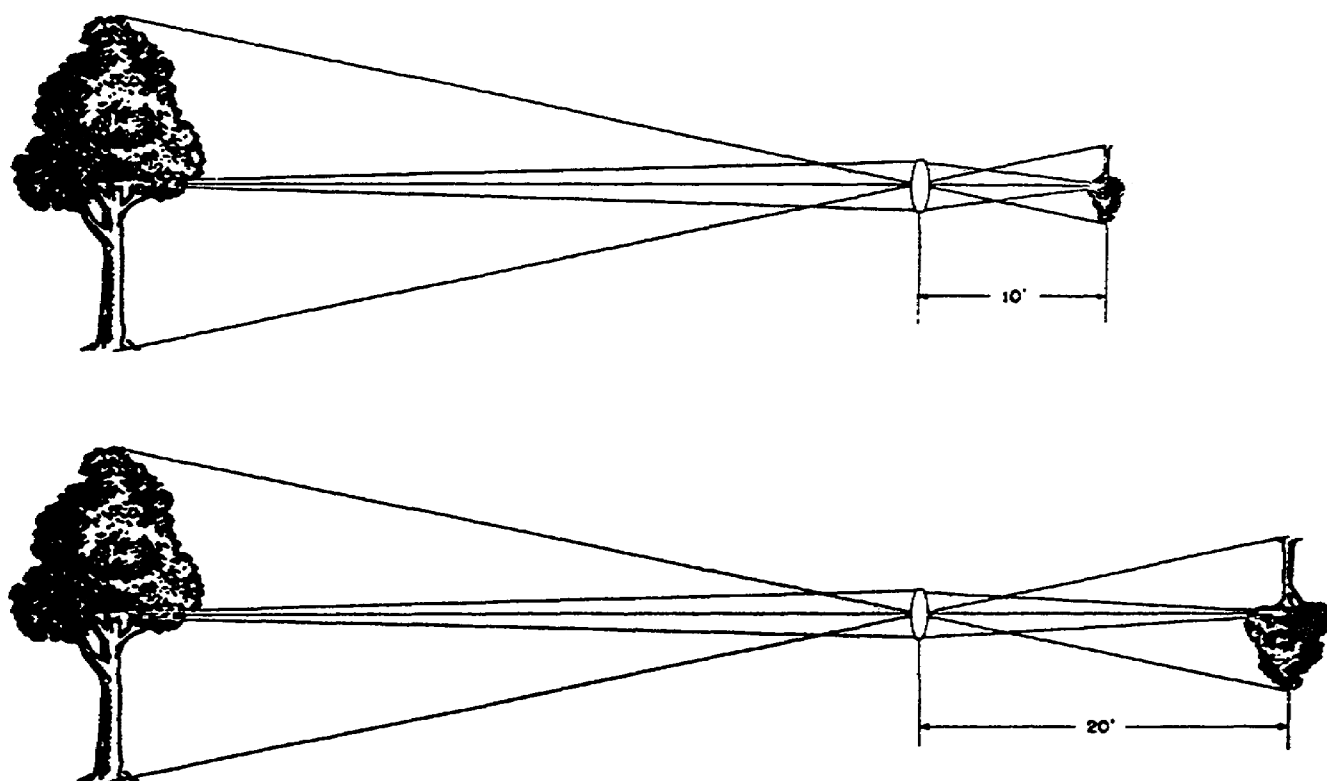


Figure 2-18. Size of image in relation to focal length.

b. The focal length of the lens most frequently used with a particular camera should be approximately the same length as the diagonal measurement of the negative size. Use of the correct lens causes the proportions of objects to be recorded as normal. Table 2-3 indicates the diagonal measurement of the more common negative sizes.

Negative sizes		Diagonals	
Millimeters	Inches	Millimeters	Inches
24x36	1x1½	43	1.8
60x60	2¼x2¼	85	3.4
60x90	2¼x3¼	108	4.3
100x125	4x5	160	6.4
130x180	5x7	220	8.7
200x250	8x10	288	12.8
264x336	11x14	426	17.75

Table 2-3. Diagonals of negatives.



## 2-13. CIRCLE OF CONFUSION.

a. Basically, a photograph is an accumulation of many points that are exact images of points composing a subject. For example, light rays striking a subject are reflected by a lens, and are reproduced on film or ground glass as circles.

b. Light rays seem to produce a "cone" of light. The apex of the cone originates at a point on the subject; the base of the cone is at the lens. When the light rays pass through the lens, the cone of light is reversed. The base is still at the lens, but the apex now lies in the focal plane. An infinite number of these cones combine to produce a photographic image.

c. If the cone of light is intersected, either in front or behind the focal plane, the light rays form circles rather than points. These are called circles of confusion, (fig 2-19). A circle of confusion is a point of light that has been enlarged due to incorrect focus. It is measured as a fraction such as  $1/250$ ,  $1/500$ , or  $1/1000$  of an inch.

d. If the circles of confusion are small enough, they are "acceptably" sharp to the eye and are said to be in focus. If the circles are large enough they appear as circles and the image, now consisting of many circles, is blurred and out of focus. It should be noted, however, that a circle of confusion may be acceptable for one photograph and unacceptable for a second type of photograph.

### e. Factors Controlling Circles Of Confusion.

(1) Focusing. Light rays form sharp points on the ground glass or film if the subject is at a correct distance from the lens in relation to the distance between the lens and the film. At this point, the image is sharp and the lens is focused properly, (fig 2-19).



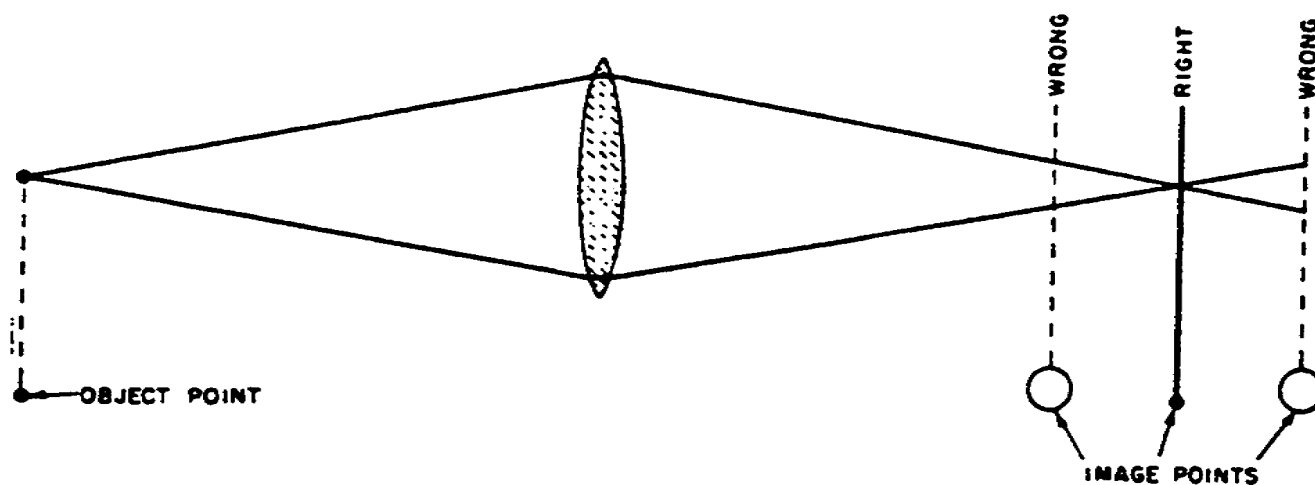


Figure 2-19. Image points nearer to and farther from focal point.

If the lens is then moved nearer to or farther from the ground glass or film, the light rays intersect in front of or behind the ground glass or film, and the image is blurred. This blur, caused by overlapping circles of confusion, can be overcome by changing the distance between the lens and the focal plane to give a minimum circle of confusion. This is called focusing.

(2) Lens speed. Another factor controlling circles of confusion is the speed or aperture of a lens. The smaller a lens opening, the less light reaches the film and the narrower the light rays falling on the film. The narrower these rays, the smaller the circles of confusion. In practice, this means that a small lens opening permits the recording of several objects at varying distances. Even if the rays from some objects do not intersect perfectly at the film plane, the circles of confusion intersecting before or behind the film are negligible and still appear sharp.

(3) Photographic prints. Another factor to consider when dealing with circles of confusion is the manner in which the negative is to be printed. Negatives used primarily for contact printing do not require as small a circle of confusion as negatives from which enlargements are to be made.

f. Size of Circle. A circle of confusion that is  $1/250$  inch in diameter is generally small enough for negatives made with 4x5-inch cameras. For miniature cameras, a  $1/1000$ -inch circle of confusion is acceptable. A uniform standard of definition in enlarging is automatically obtained by establishing the value of the circle of confusion as  $1/1000$  of the focal length at the photographic recording lens of larger cameras, and  $1/2000$  of the focal length for miniature cameras. This is better than using arbitrary figures that vary with different focal length lenses.



---

## REVIEW EXERCISES

10. What is the usable portion of a circle illumination called? \_\_\_\_\_  
\_\_\_\_\_.

11. How many degrees angle of field does a normal lens have? \_\_\_\_\_  
\_\_\_\_\_.

12. What factors affect angle of view on the negative?  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_.

13. In a normal lens, what is the focal length equal to?  
\_\_\_\_\_  
\_\_\_\_\_  
(complete statement)

14. Which of the following lenses has the smallest angle of view? (Underline one.)

a. Long focal length lens

b. Normal focal lens

c. Wide-angle lens

15. What is the diagonal, in millimeters, of the following negative sizes?  
a. 24 x 36mm \_\_\_\_\_  
b. 4 x 5 inch \_\_\_\_\_  
c. 200 x 250mm \_\_\_\_\_.

16. What is a 'circle of confusion'?  
\_\_\_\_\_.



17. What are the three factors controlling circles of confusion?

\_\_\_\_\_, \_\_\_\_\_,

\_\_\_\_\_.

#### 2-14. CONJUGATE DISTANCE.

a. The distance between a subject and a photographic lens varies inversely with the distance from the lens to the focal plane. These distances are called conjugate distance; that is, the total distance from the subject to the focal plane, (fig 2-20).

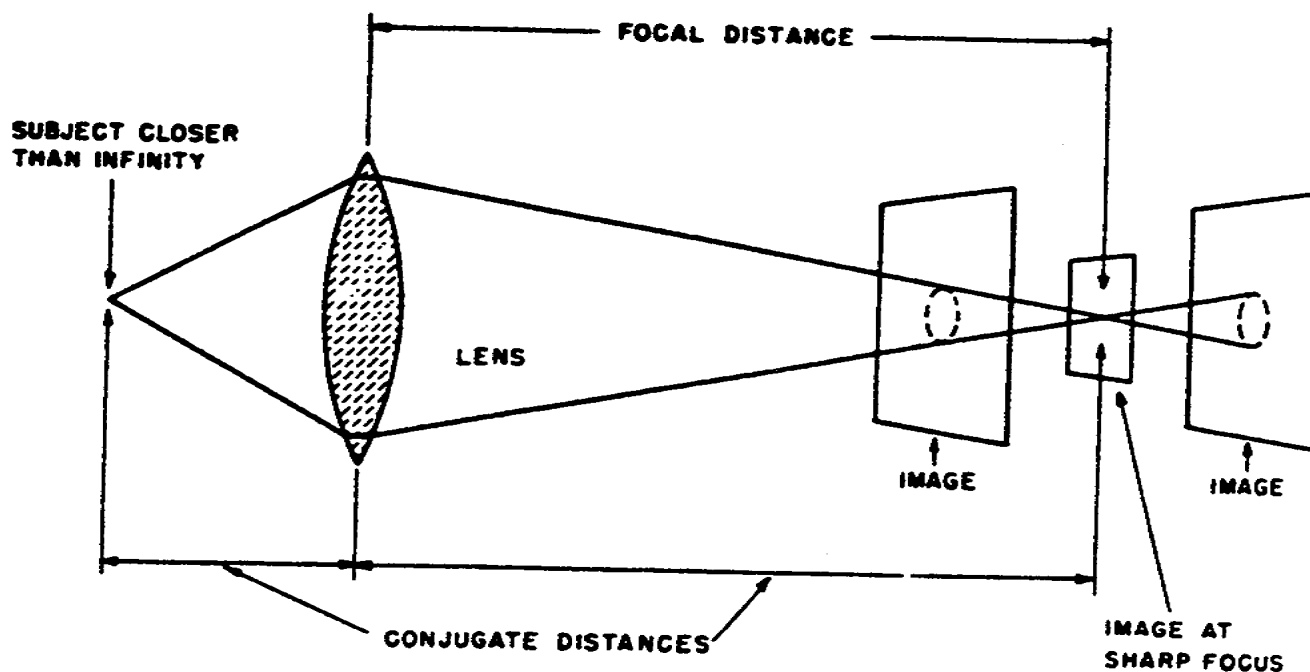


Figure 2-20. Conjugate distance.

b. When we say that these distances vary inversely, we mean that one distance increases as the other decreases, and vice versa. In other words, when the lens-to-subject changes, the lens-to-film distance must change. When the lens-to-subject distance increases, the lens-to-film distance decreases, (fig 2-21a). Similarly, if the lens-to-subject distance decreases, the lens-to-film distance will increase, (fig 2-21b).



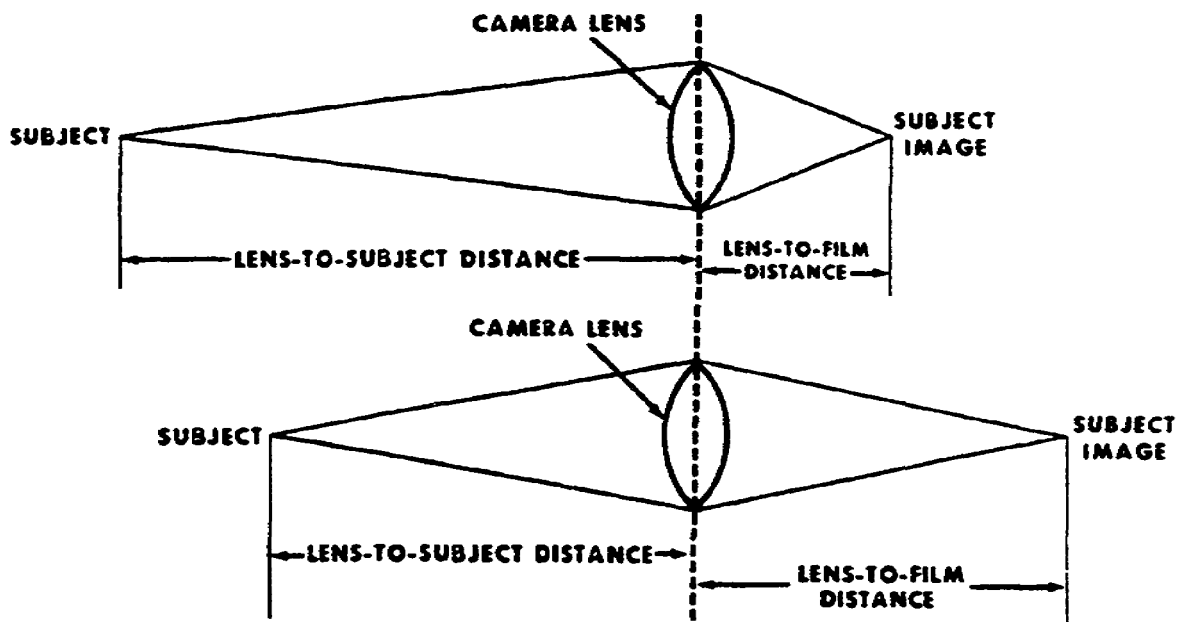


Figure 2-21. Effect of lens-to-subject distance on lens-to-film distance.

c. Use of Conjugate Distances. Let us assume that you are to photograph a tool that is 12 inches long. The image is to be 6 inches long, and you are to use a camera with a 12-inch lens to accomplish your work.

(1) The first step is to determine the scale of the photograph by using the formula below.

Where I = Image length, O = Object length, and S = Scale.

$$\text{SCALE} = \frac{I}{O} \text{ or } S = \frac{I}{O} \quad \frac{6}{12} \text{ or } S = \frac{1}{2} \quad \text{Scale is } 1:2$$

(2) The next step is to use the formula below to determine the image distance.

Image Distance = Focal Length x (Scale plus 1) or

$$ID = FL \times (S + 1) \text{ or } 12 \times (\frac{1}{2} + 1) = 12 \times 1\frac{1}{2} = 18$$

$$ID = 18$$

In other words, the lens should be 18 inches from the film.

(3) The last step is to use the formula below to determine object distance.

$$\text{Object Distance} = \frac{\text{Image distance}}{\text{scale}} \quad \text{or } OD = \frac{ID}{S} = \frac{18}{\frac{1}{2}}$$

$$OD = 36$$

The lens should be 36 inches from the object.

**NOTE:** When working these problems you will find it easier to convert scale to a decimal; e.g.,  $\frac{1}{2}$  or 1:2 becomes .5,  $\frac{1}{3}$  or 1:3 becomes .33, and  $\frac{1}{4}$  or 1:4 becomes .25.

## 2-15. FOCUSING LENS FOR ONE OBJECT.

a. When light rays from a far object pass through a lens, they form a sharp image close to the lens. When light rays from a near object pass through a lens, they form a sharp image farther from the lens. This means that the lens must be focused on either the far or the near object, depending on which one the photographer wants to be sharp. If a sharp image of the near object is desired, the lens should be focused by moving it farther away from the ground glass or film. If a sharp image of the far object is desired, the lens must be moved closer to the ground glass or film.

b. Figure 2-22 illustrates this process. Light coming from far object, A, passes through the lens to form a sharp object at A<sub>1</sub>, and light coming from the nearer object, C, passes through the lens to form a sharp image at C<sub>1</sub>.

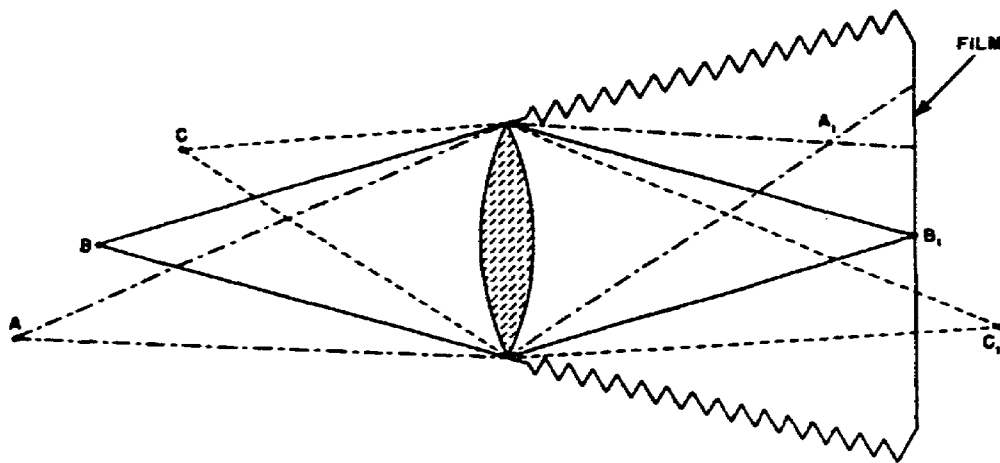


Figure 2-22. Focusing for one object.

c. To obtain a sharp image of object A, move the film to A<sub>1</sub>. To obtain a sharp image of object C, move the film to C<sub>1</sub>. This process of moving the focal or film plane of a camera to the point of intersection of a given ray is called focusing.





## 2-16. RESOLVING POWER.

a. The resolving power of a lens, also called the definition of a lens, is its ability to reproduce fine lines. Resolving power is usually measured in lines per millimeter. Thus, if the resolving power of a lens is 100 lines per millimeter, the lens records 100 definitely separated lines per millimeter. Most high quality lenses have a resolving power that far exceeds the resolving power of film.

b. Two factors that influence the definition of a lens are the quality of the lens and diffraction. The maximum definition of any lens depends on the minimum circle of confusion. This, in turn, is controlled by the quality of the lens. Geometric limitations in lens design make it impossible to create a lens of uniform quality from center to edge.

c. The edges retain aberrations that greatly affect definition. Accordingly, most manufacturers recommend use of the optimum aperture of a particular lens. This refers to the aperture at which the lens operates best. The optimum aperture is normally two to two and a half stops above the maximum aperture of the lens. If you have a lens that is rated at  $f/2$ , the optimum aperture would probably be between  $f/4$  and  $f/5.6$ .

## 2-17. DEPTH OF FIELD.

a. Depth of field is the distance from the nearest point of acceptable sharp focus to the farthest point of acceptable sharp focus of a subject being photographed, (fig 2-23).



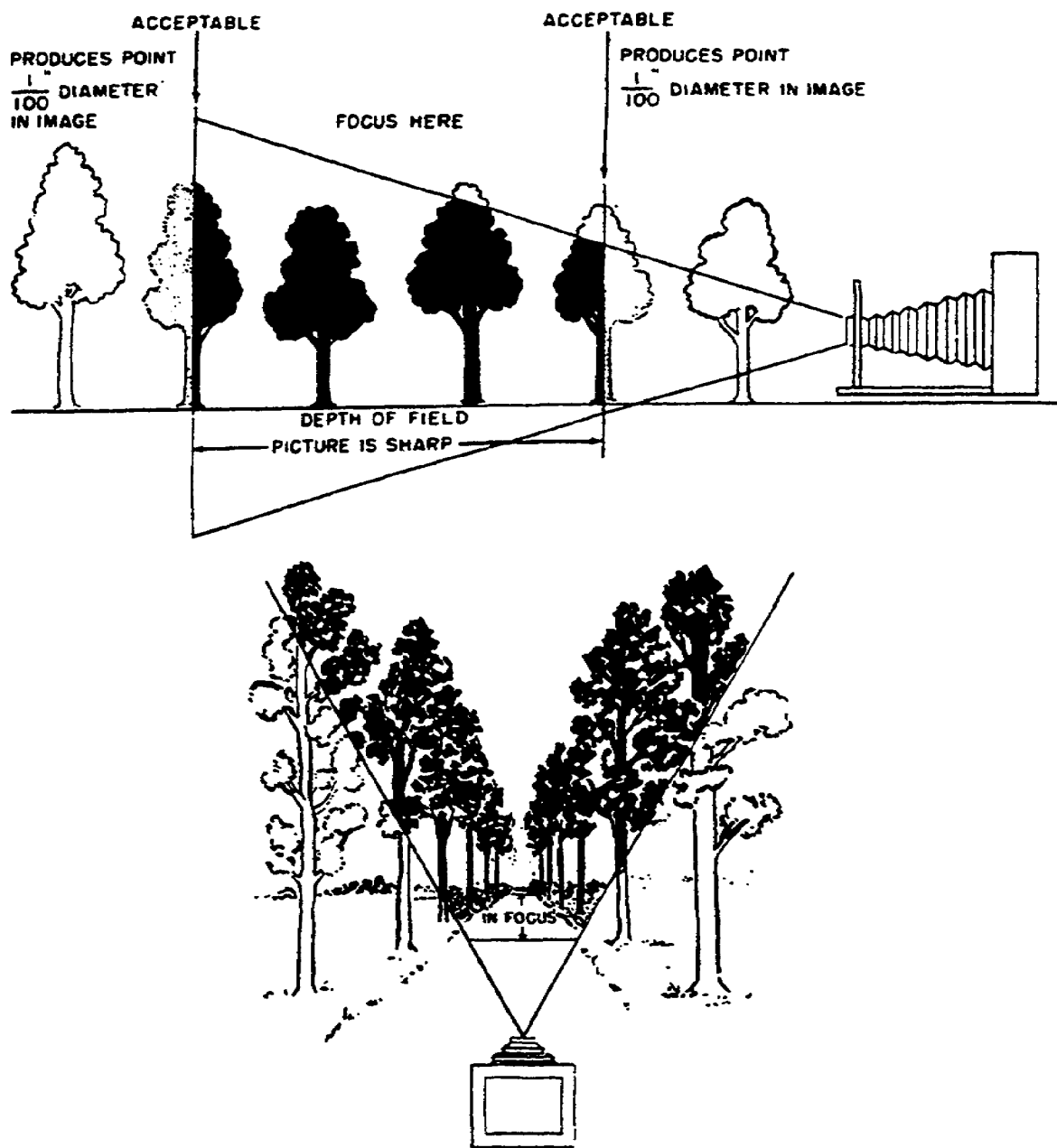


Figure 2-23. Depth of field.

Because most subjects exist in more than one plane and have depth, it is important in photography to have an area in which more than just a narrow vertical plane will appear sharp. Depth of field depends on the focal length of the lens, the lens stop, the distance from the point in focus to the lens, and the size of the circle of confusion.

b. Assume that a camera with a long focal length lens, and a camera with a short focal length lens, are placed at equal distances from a subject. In this case, the depth of field is greater with the short focal length lens than with the long focal length lens.

c. Depth of field also increases as the lens opening or aperture is decreased, because the size of each cone of light decreases in proportion to the aperture. The top and center sections of figure 2-24 show that a lens with a large aperture reproduces sharply only those objects located between B and D. In the lower sections, the sharpness range of the depth of field is increased to the distance of A to E, because the lens diaphragm has been closed down to a smaller aperture.

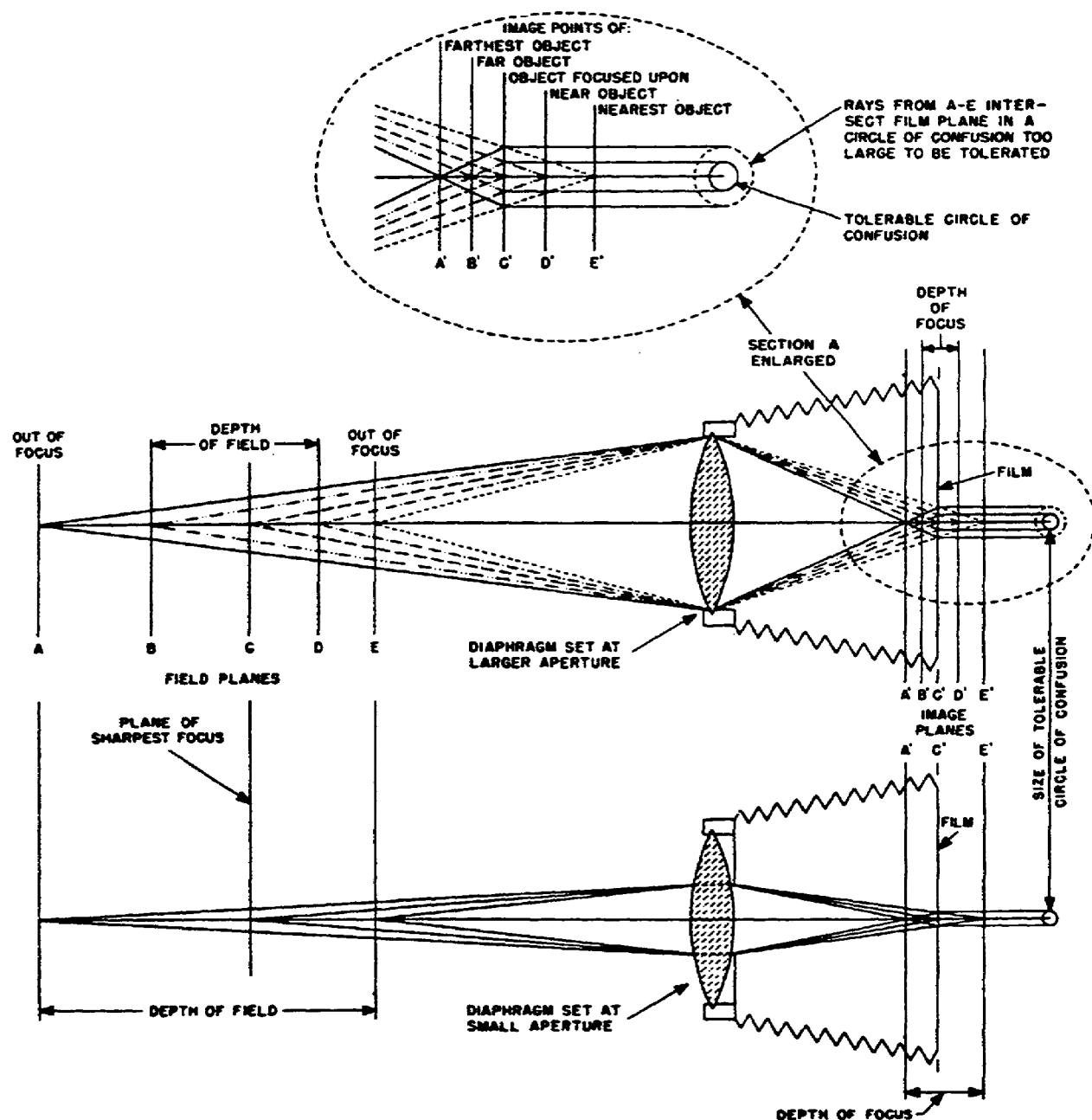


Figure 2-24. Effects of diaphragm opening on depth of field.

d. If a lens is focused on a nearby object (short distance setting), the depth of field is also short. If the distance setting is increased (lens focused on a more distant object), the depth of field increases (fig 2-25). For this reason, it is important to focus more accurately for pictures of nearby objects than for distant objects.

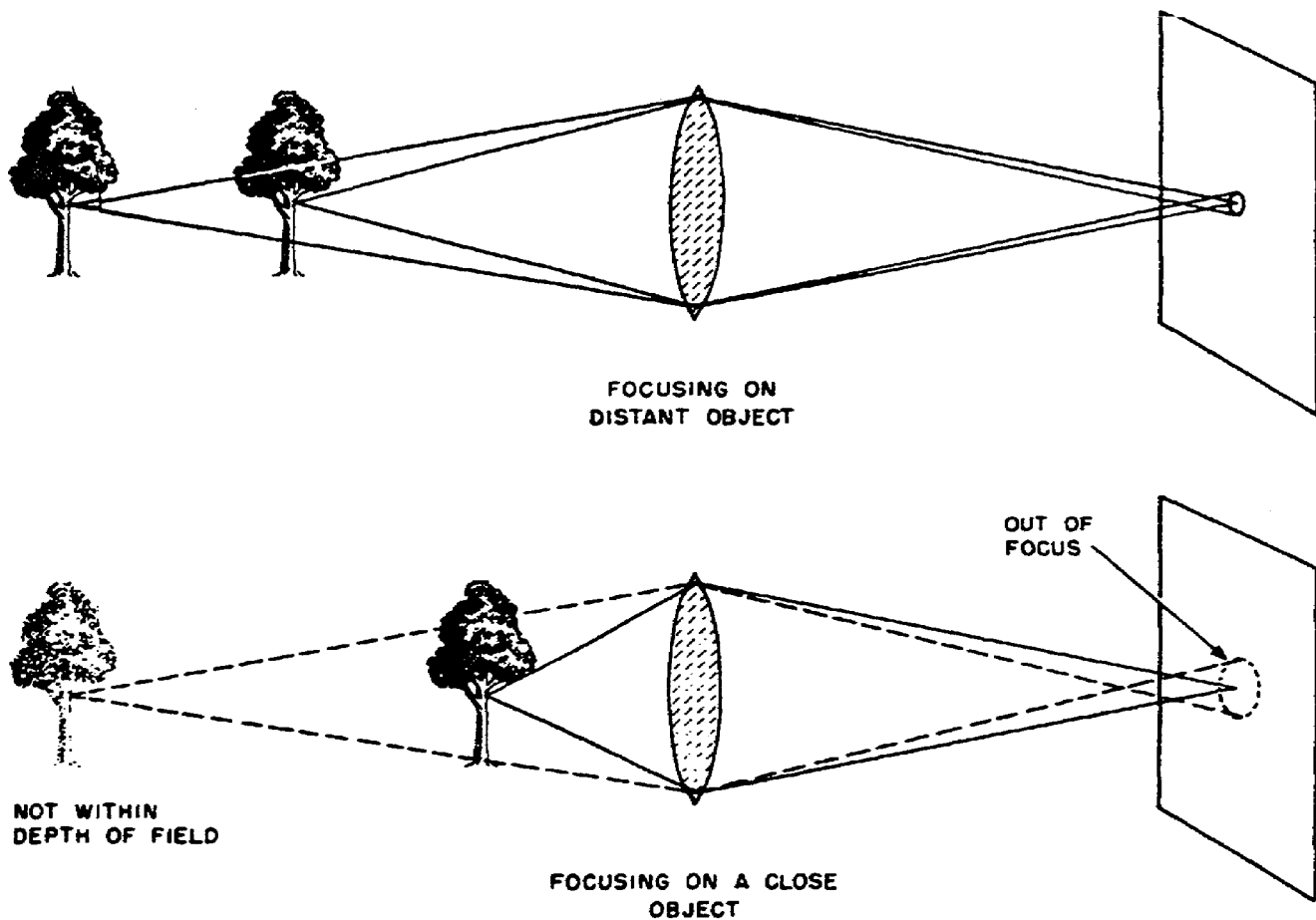


Figure 2-25. Effects of distance on depth of field.

e. Accurate focus is also essential when using a large lens opening. A small f/stop compensates for minor inaccuracies. If enlargements are to be made from a negative, focusing must be extremely accurate.

2-18. FOCUSING LENS ON SEVERAL OBJECTS. When you are focusing a lens on several objects that are at different distances from the lens, you must effect a compromise. You usually obtain the best results by focusing on a point one-third ( $1/3$ ) of the distance between the nearest (C) and farthest (A) point of focus, (fig 2-26).



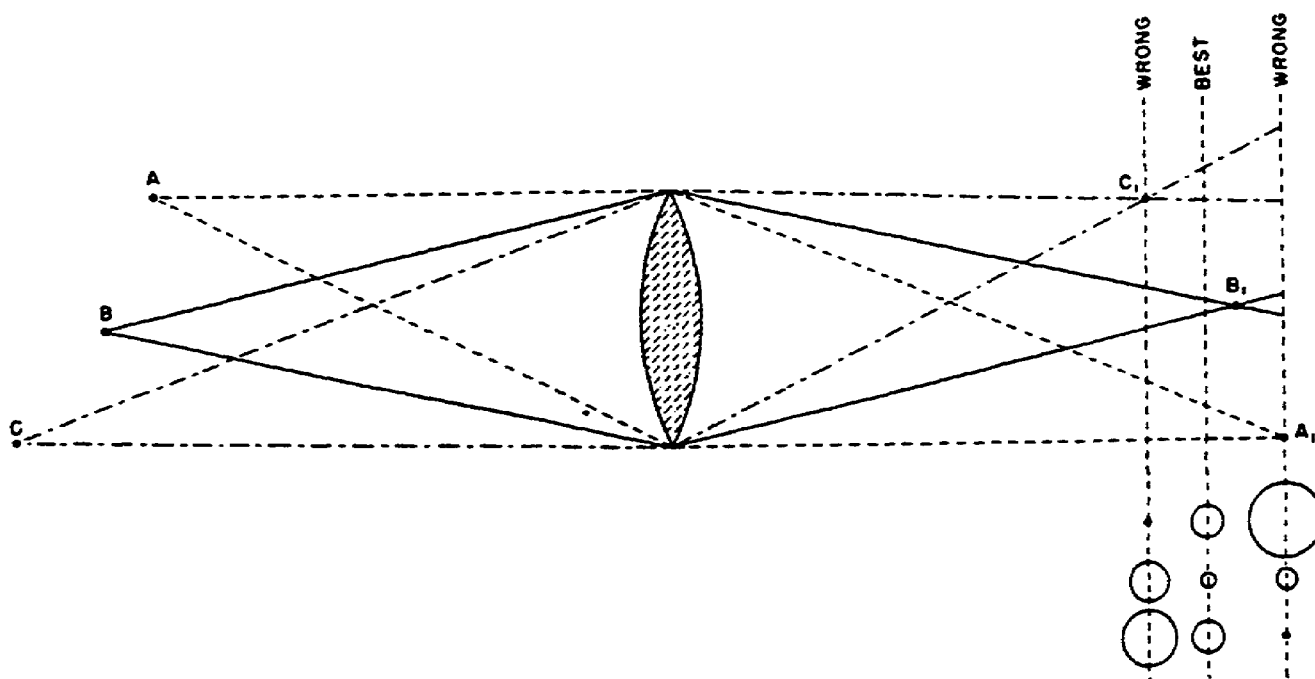


Figure 2-26. Focusing one-third of the distance.

2-19. DEPTH OF FOCUS. Depth of focus is the distance the focal plane can be moved forward and backward from the point of exact focus and still retain an image of acceptable sharpness. (Figure 2-27 shows the area within which movement is possible.)

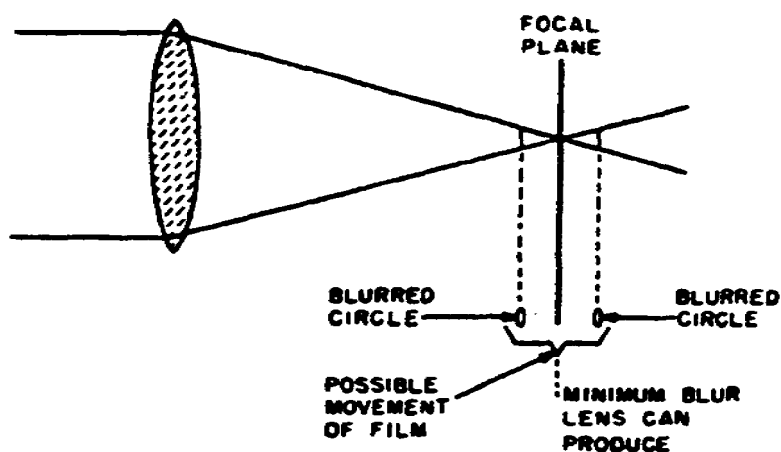


Figure 2-27. Depth of focus.





2-20. DEPTH OF FIELD INDICATOR. Some cameras have depth of field indicators to show the approximate depth of field at various distances when using different lens stops. Figure 2-28 shows two settings, one when the lens is focused at 6 feet (on the left) and one when the lens is focused at 25 feet (on the right).

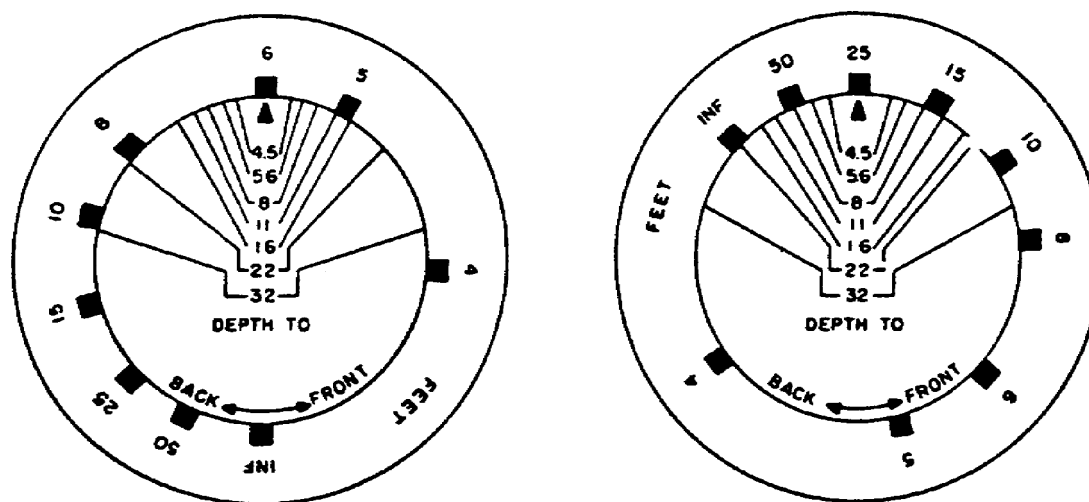


Figure 2-28. Depth of field indicator.

a. In the setting on the left figure, the lens is focused at 6 feet. The depth of field is as follows:

<u>SETTING</u>	<u>DEPTH OF FIELD</u>
f/4.5	5 3/4 to 6 1/4 ft.
f/5.6	5 1/2 to 6 1/2 ft.
f/8	5 1/4 to 6 3/4 ft.
f/11	5 to 7 ft.
f/16	5 to 7 1/2 ft.
f/22	4 3/4 to 8 ft.
f/32	4 1/4 to 10 ft.

b. In the setting on the right (above), the lens is focused at 25 feet. The depth of field is as follows:

<u>SETTING</u>	<u>DEPTH OF FIELD</u>
f/4.5	37 to 22 ft
f/5.6	45 to 18 ft
f/8	50 to 16 ft
f/11	65 to 14 ft
f/16	100 to 13 ft
f/22	Inf to 11.5 ft
f/32	Inf to 9 ft



c. The depth of field scale is especially useful when you must know the exact sharpness range of the camera lens at various distance and aperture settings. This enables you to include objects at various distances within the area of focus.

---

## REVIEW EXERCISES

18. Describe, in your own words, the meaning of "conjugate distance".

---

---

---

19. What is meant by "distances vary inversely"?

---

---

---

20. List the formulas used with the "conjugate distances.

a.

b.

c.

21. When light rays from a near object pass through the lens, they form a sharp image behind the ground glass. To bring this image into sharp focus, which way should you move the lens? \_\_\_\_\_

---

22. What is meant by the resolving power of a lens?

---

---



23. What is meant by the optimum aperture of a particular lens?

---

24. What is "depth of field"?

---



---

25. When you are focusing on several objects at the same time, how can you make sure that you get all of the objects in focus when they are at different distances from the camera?

---



---

26. What is meant by "depth of focus"?

---



---

27. Using the illustration (right), identify and list the various f/stops and depth of field distances.

Setting (f)

Depth of field(ft.)

---

to

---

to

---

to

---

to

---

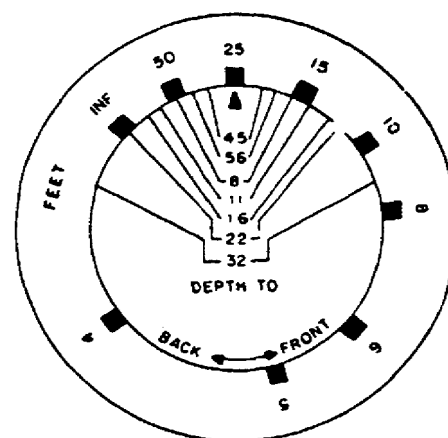
to

---

to

---

to




---



# SECTION IV

## PRACTICAL CAMERA LENS DATA

2-21. GENERAL. Photographers often require conversion tables and simple formulas to work out camera lens settings and reproduction ratios. This section contains information to solve some of these common problems in photography.

2-22. CAMERA LENS SIZE CONVERSION TABLE. When working with photographic lenses, the photographer will often be faced with the problem of converting relatively small measurements from inches into millimeters, or from millimeters into inches. Table 2-4 greatly simplifies conversion of such measurements.

Milli- meters	Inches	Milli- meters	Inches	Milli- meters	Inches	Milli- meters	Inches
15	3/5	105	4 1/5	240	9 3/5	340	13 3/5
20	4/5	110	4 2/5	250	10	350	14
25	1	120	4 4/5	255	10 1/5	360	14 2/5
30	1 1/5	125	5	260	10 2/5	365	14 3/5
35	1 2/5	135	5 2/5	275	11	375	15
40	1 5/8	150	6	280	11 1/5	385	15 2/5
45	1 4/5	165	6 3/5	285	11 2/5	400	16
50	2	170	6 4/5	290	11 3/5	415	16 3/5
70	2 4/5	175	7	300	12	425	17
80	3 1/5	200	8	315	12 3/5	450	18
85	3 2/5	205	8 1/5	320	12 4/5	475	19
90	3 3/5	225	9	325	13	485	19 2/5
100	4	235	9 2/5	330	13 1/5	500	20

Table 2-4. Camera lens size conversion table.

2-23. FOCAL LENGTH. Focal length is the distance from the optical center of a lens to the film plane when the lens is focused at infinity. Focal length is calculated by the manufacturer when the lens is made. It is stamped on the lens barrel.





## 2-24. REPRODUCTION RATIO.

When copying an object, the size of the reproduction compared with the original, depends on the focal length of the lens and the distance between the original and the camera. The greater the focal length, the larger the copy.

a. A 400mm lens produces copy twice the size of copy made with a 200mm lens, if the original is the same distance from the lens. The farther an object is from the camera, the smaller the copy. However, in this case, the size is not directly proportional (inversely) to the distance. An 11x14-inch original copied so that the long side becomes 7 inches undergoes a linear reduction of one-half ( $\frac{14}{2} = 7$ ). The number obtained by dividing any length in

7 the original by its length in the copy is the reduction figure (ratio).

b. When speaking of reduction of size in copying, linear reduction is always meant unless the contrary is stated. Reproduction ratio is defined as any linear distance on the image divided by the corresponding distance on the original. Reproduction ratio refers to either reduction or enlargement, whichever is applicable at the time. The following formula is used:

$$\frac{\text{Image size}}{\text{Object size}} = \text{Ratio}$$

c. Scale is the measurement of a reproduction as compared to the corresponding measurement of the original. A scale of 1:1 means the scale of reproduction is equal to the scale of the original. A scale of 1:2 means that the reproduction is one-half the size of the original. A scale of 2:1 means that the reproduction is two times the size of the original.

2-25. CAMERA BELLOWS EXTENSION. Normally, a camera lens can be focused from 6 feet to infinity and retain its f/number value. At close lens-to-subject distances, however, the distance between the lens and focal plane becomes so great that the film does not receive the amount of light indicated by the marked f/number. When the camera is moved to a point closer than ten times the focal length from the subject, compensation must be made for light lost due to the bellows extension. This compensation is made by application of a multiplying factor.



a. Multiplying factor. The multiplying factor for a critical exposure is determined in the following manner:

$$\text{Multiplying Factor} = \left( \frac{\text{bellows extension}^2}{\text{focal length}} \right) \text{ or } \left( \frac{\text{BE}^2}{\text{FL}} \right)$$

Example: If a 6-inch lens is used with a 12-inch bellows, the multiplying factor is -

$$\text{Multiplying Factor} = \left( \frac{12}{6} \right)^2 = 2^2 = 4$$

b. Use of multiplying factor.

(1) As explained previously, each lens stop passes twice as much light as the lens stop above it. For example, f/4 passes twice as much light as f/5.6, four (2x2) times as much light as f/8, eight (2x2x2) times as much light as f/11, sixteen (2x2x2x2) times as much light as f/16, etc.,

(2) The multiplying factor indicates the number of times that exposure must be increased. For example, a multiplying factor of 4 (2x2) indicates that the lens must be opened two lens stops beyond the exposure setting for an object at a normal 6-foot distance; a multiplying factor of 8 (2x2x2) indicates that the lens must be opened three stops beyond the normal exposure setting; and a multiplying factor of 16 (2x2x2x2) indicates a need for opening the lens four stops beyond the exposure setting normally used at the 6-foot distance.

---

## REVIEW EXERCISE

28. You have an original document that is 8x10-inches and you must make a reproduction that is 4x5-inches. What is the ratio? \_\_\_\_\_

29. You are given a chart that is 3x5-inches and asked to copy it at a ratio of 2:1. What size will the copy be? \_\_\_\_\_



30. Using an 8x10-inch copy camera, with an 8-inch lens and 16-inch bellows extension, what is the multiplying factor to obtain the correct exposure?

Formula:

$$\text{Multiplying factor} = \frac{(\text{bellows extension})^2}{\text{focal length}} = \frac{\quad}{\quad} \text{ (answer)}$$

.....

2-26. SUMMARY: You have now completed lesson 2 of the subcourse. This lesson has dealt with the basic optics, to include lens characteristics, focal plane, focal length, lens performance factors, plus some general practical camera lens data. This lesson was designed to give you a general knowledge about optical functions and some of the applications in general photography. You will have to apply the knowledges gained in this lesson to a number of tasks required of you in your job as an 84B.



## LESSON 2

### EXERCISE SOLUTIONS

1. A pinhole in a piece of thin metal or black paper, (para 2-3).
2. FALSE, (para 2-3).
3. True, (para 2-4c).
4. (L to R) c, a, d, b, e, f, (para 2-5).
5. Positive lenses, a, d; negative lenses, b, c; (para 2-5a and b).
6. The plane in which the image is sharply formed, (para 2-6a).
7. The focal length, (para 2-6b).
8. Focal length, (para 2-6c).
9. Lens aperture, (para 2-7b).
10. Circle of good definition, (para 2-9).
11. 450 to 550, (para 2-9a).
12. Focal length of lens, film size, and subject distance, (para 2-10b).
13. Diagonal of the negative, (para 2-10b(1)).
14. a. Long focal length lens, (para 2-10b (4) fig 2-17)).
15. a. 43mm.  
b. 160mm.  
c. 288mm, (para 2-12b table 2-3).
16. A point of light that has been enlarged due to incorrect focus, (para 2-13c).
17. Focusing, lens speed, photographic prints, (para 2-13e(1)(2)(3))





18. It is the total distance from the subject to the focal plane, (para 2-14a).
19. One distance increases as the other decreases or visa versa, (para 2-14b).
20.
  - a. 
$$S = O \frac{I}{O}$$
  - b. 
$$ID = FL \times (S + 1).$$
  - c. 
$$OD = S \frac{ID}{S}$$

(para 2-14c(1)(2)(3)).
21. Move the ground glass farther away from the lens, (para 2-15a).
22. The ability to reproduce fine lines, (para 2-16a).
23. Normally two to two and a half stops above the maximum aperture of the lens, (para 2-16c).
24. It is the distance from the nearest point of acceptable sharp focus, to the farthest point of acceptable sharp focus of a subject being photographed, (para 2-17a).
25. By focusing on a point one-third of the distance between the nearest and farthest point of focus, (para 2-18).
26. The distance the focal plane can be moved forward and backward from the point of exact focus and still retain an image of acceptable sharpness, (para 2-19).
27. 

Setting	Depth of field
f/4.5	13 to 18 ft.
f/5.6	12 to 21 ft.
f/8	11 to 24j ft.
f/11	10 to 28 ft.
f/16	91 to 35 ft.
f/22	9 to 47 ft.
f/32,	7½ to INF., (para 2-20).
28. 1:2, (para 2-24b).
29. 6x10-inches, (para 2-24c).
30. 4, (para 2-25a).



